

1 **APPENDIX A**
2 **DEFINING COATING DESTRUCTION PRESSURES AND COATING**
3 **DEBRIS SIZES FOR DBA-QUALIFIED AND ACCEPTABLE COATINGS**
4 **IN PRESSURIZED WATER REACTOR (PWR) CONTAINMENTS**

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PURPOSE

This paper has been prepared to provide coating destruction pressure data for use in defining the coating Zone of Influence (ZOI) and coating debris sizes for DBA-qualified and Acceptable coatings in Pressurized Water Reactor (PWR) containments.

DISCUSSION

The criteria for DBA-qualification of coating systems in PWR containments are contained in ANSI N101.2, "Protective Coatings (Paints) for Light Water Nuclear Reactor Containment Facilities (Reference A-1)," and its successor document, ASTM D 3911, "Standard Test Method for Evaluating Coatings Used in Light-Water Nuclear Power Plants at Simulated Design Basis Accident (DBA) Conditions (Reference A-2)." Both of these national standards are essentially identical in their requirements for DBA-qualification of coatings:

1. Fully-cured coated panels are placed in an autoclave chamber. Note that, by test method requirements, the panels are positioned such that they are not subject to direct steam impingement.
2. Using saturated steam, the autoclave pressure and temperature are adjusted to produce conditions approximating the DBA environment within a PWR containment structure.
3. After completion of the DBA cycle, each panel is examined.

The US Nuclear Regulatory Commission reviewed ASTM D 3911-95 and found it "...acceptable to the NRC staff for the...qualification... of protective coatings applied in nuclear power plants," as stated in Regulatory Guide 1.54 Revision 1 (Reference A-3).

Nuclear plants licensed prior to the issuance of ANSI N101.2 selected and tested coating systems for use in containment by virtue of sound engineering practices. Containment coatings by this pre-ANSI N101.2 process are designated as "Acceptable" as defined in ASTM D5144-00 (Reference A-4):

"Acceptable Coating or Lining System – A safety-related coating or lining system for which a suitability for application review which meets the plant licensing requirements has been completed and there is reasonable assurance that, when properly applied and maintained, the coating or lining will not detach under normal or accident conditions."

In most cases, the coating products and systems applied in PWR containments in pre-ANSI N101.2 plants are generically comparable to those used in post-ANSI N101.2 plants. These coating materials were system combinations of epoxy surfacers; inorganic zinc primers, epoxy and epoxy phenolic primers; and epoxy and epoxy phenolic topcoats.

As part of the overall regulatory investigation of GSI-191, Savannah River Technology Center (SRTC) was engaged by the US Nuclear Regulatory Commission Division of Engineering

1 Technology Office of Regulatory Research to "...investigate the potential for degradation and
2 failure of such coating systems (safety-related coatings located inside containment, ed.) when
3 subjected to DBA conditions, and to characterize failed coating debris..." (Reference A-5), and,
4 "...investigate the performance and potential for debris formation of Service Level I
5 (safety-related coatings located inside containment, ed.) used in nuclear power plant
6 containment..." (Reference A-6). The two major findings concerning the performance of
7 DBA-qualified coatings in PWR containment service which resulted from the SRTC research are
8 presented in References 5 and 6 as follow:

9 Reference 5:

10 "Properly applied coatings that would contain only minor defects and that have not been
11 subjected to irradiation of 10^9 rads, can be expected to remain fully adhered and intact on
12 a concrete substrate (emphasis added, ed.), following exposure to simulated DBA-LOCA
13 conditions."

14 Reference 6:

15 "Properly applied coatings that have not been subjected to irradiation of 10^9 rads, can be
16 expected to remain fully adhered and intact on a steel substrate (emphasis added, ed.),
17 following exposure to all simulated DBA-LOCA conditions."

18 Thus, the independent research by SRTC on behalf of the USNRC validates the DBA test
19 methodology for containment coatings contained in ANSI N101.2 and ASTM D 3911.

20 The test method defined in ANSI N101.2 and ASTM D 3911 is not designed to provide data
21 concerning the performance of coatings exposed to direct impingement of fluids. Understanding
22 the performance of DBA-qualified protective coatings in fluid impingement conditions is
23 necessary to quantify coating debris generation during a DBA and its contribution (quantity and
24 debris size) to the overall debris source term.

25 **TEST PROGRAM**

26 A test program was designed and undertaken by Florida Power and Light and the Westinghouse
27 Owners' Group (WOG) to determine the minimum destruction jet temperatures/pressures for
28 PWR containment coatings and resultant coating debris particle size. The testing was conducted
29 at the Florida Power and Light St. Lucie Nuclear Station, located on Hutchinson Island, Florida
30 on April 8, 2004. The test program and its results are described in Attachment A.

31 The testing consisted of 3,500 psig waterjetting of a selection of DBA-qualified PWR
32 containment coatings applied to steel and concrete substrates, employing 195 deg F water, a
33 15 degree waterjet tip, and angles of attack of 90 degrees and <45 degrees. Water contact
34 temperature at the surface being waterjetted was measured at 150 deg F using a contact
35 pyrometer. Unless premature coating failure occurred, all test durations were 60 seconds. The
36 surface preparation and coating application of the test samples were performed in accordance

with the Florida Power and Light safety-related (Service Level 1) coating specification. The coatings systems tested were:

- A. steel substrate, untopcoated inorganic zinc,
- B. steel substrate, inorganic zinc primer, two coats of epoxy,
- C. steel substrate, two coats of epoxy,
- D. concrete substrate, cementitious epoxy surfacer, two coats of epoxy, and,
- E. concrete substrate, two coats of epoxy.

To investigate the effect of fluid jet temperature on minimum coating destruction jet pressure, additional testing was performed on the coating test panels using ambient temperature (~ 80 deg F) 3,500 psig water jetting. With the exception of the untopcoated inorganic zinc samples, no destruction of the coating surfaces was observed.

TEST PROGRAM RESULTS

All observed coating failures were cohesive as manifested as loss of thickness by erosion rather than production of coating flakes and chips or loss of adhesion (delamination).

Additional detailed observations of the testing performed are:

1. At 3,500 psig jet pressure, 150 deg F surface contact temperature, 15-degree tip, 6 in. standoff, 90 degree angle of attack, all coatings tested failed by erosion to some extent.
2. At 3,500 psig jet pressure, 150 deg F surface contact temperature, 15-degree tip, 6 in. standoff, <45 degree angle of attack, no coating failure by erosion occurred, with the exception of untopcoated inorganic zinc, which did fail by erosion.
3. At 3,500 psig jet pressure, 150 deg F surface contact temperature, 15-degree tip, 18 in. standoff, 90-degree angle of attack, untopcoated inorganic zinc lost approximately 50% of its original dry film thickness due to erosion during the 60 second test duration.
4. At 3,500 psig jet pressure, 150 deg F surface contact temperature, 15-degree tip, 21 in. standoff, 90-degree angle of attack, untopcoated inorganic zinc did not fail by erosion or other mechanisms.
5. No visible coating debris was observed during the testing. As such, the coating debris was judged to be less than 50 μ m, which is the lower bound size of particulate matter that can be seen with the naked eye.

6. In the epoxy coatings tested, anomalies which could be normally expected in coatings applications (pinholes, etc) and artificial coating defects (the cut scribes) were nucleation sites for coating failure by erosion.
7. The 90 degree angle of waterjet attack was significantly more aggressive than the <45 degree angle of attack.
8. The elevated temperate (150 deg F) water jet at 3,500 psig, 15-degree tip, 6 in. standoff, resulted in coating destruction; the ambient (~ 80 deg F) water jet at 3,500 psig, 6 in. standoff, did not result in coating destruction (with the exception of untopcoated inorganic zinc).

FINDINGS

1. With the exception of untopcoated inorganic zinc, protective coating systems which are DBA-qualified per ANSI N101.2 or ASTM D3911, and "Acceptable" coating systems generically comparable to those later DBA qualified, will have rapid erosion due to a waterjet having parameters of 3,500 psig, 150 deg F surface contact temperature, 15-degree tip, 90-degree angle of attack and 6 inch standoff distance.
2. The untopcoated inorganic zinc coating was observed to rapidly erode at a standoff distance of up to 3 times greater the value of the other coating systems tested. Untopcoated inorganic zinc did not erode at 3,500 psig jet pressure, 150 deg F surface contact temperature, 15 degree tip, 21 in. standoff, and 90 degree angle of attack.
3. Coating debris produced within the coating ZOI by the erosion of DBA-qualified/Acceptable coatings resulting from simulated LOCA jet impingement were not visible to the naked eye and, as such, were judged to be no larger than 50 μm . The debris generated by erosion can be no smaller than their constituent pigment size (10 μm).

At the same pressure, standoff distance, tip diameter, and angle of attack, the elevated temperature water jet was more destructive than the ambient temperature water jet.

OBSERVATIONS

The observations used to define the Coatings ZOIs below include:

- a. Based on the experimental data reported herein, increasing the temperature of the fluid jet results in coating degradation at lower jet pressure.
- b. Untopcoated inorganic zinc was observed to fail by erosion at jet pressures 3 times less than those observed for organic (epoxy and epoxy-phenolic) coating system failures by erosion.

- 1 c. DBA-qualified/Acceptable coatings have maximum 5-hour coating temperature
2 exposure limits in wet conditions of up to 340 deg F without direct impingement, as
3 supported by ANSI N101.2 and ASTM D 3911 DBA historical test data.
- 4 d. In the case of a typical PWR large break LOCA, pressure falls below 1,000 psig at
5 the break within 10 to 15 seconds, and break pressure reaches containment ambient
6 within 20 – 25 seconds. Break pressure does not drop nearly as rapidly for small
7 breaks. The break pressure drops to 1,400 to 1,500 psig within about one hundred
8 seconds even for a two-inch break. The jet pressure in both cases drops rapidly as
9 distance from the break increases.
- 10 e. In the case of large break LOCA, coatings exposed to a 550 deg F
11 (1089 psig).saturated steam jet for a period less than 10 to 15 seconds is beyond the
12 normal test protocols for DBA-qualification testing of PWR containment coatings.
13 Due to the relatively short duration of high temperature exposure and heat sink
14 properties of the coated substrates, the maximum bulk temperature of the coating
15 will be below 340 deg F and, as such, the coating can be judged not to fail
16 (disbond) due to elevated temperature exposure. This is supported by experimental
17 data generated by SRTC (References 5 and 6).

18 CONCLUSIONS

19 Based upon the experimental and historical data reported herein, the following conclusions can
20 be drawn:

- 21 a. The pressure defining the ZOI for DBA-qualified/Acceptable organic (epoxy and
22 epoxy-phenolic) coatings is defined as 1,000 psig,
- 23 b. The pressure for defining the ZOI for DBA-qualified/Acceptable untopcoated
24 inorganic zinc coatings is defined as 333 psig,
- 25 c. Conservatively, coatings within the Coating ZOI will fail by erosion and produce
26 fine particulate debris in sizes ranging from 10 to 50 μm .

27 The pressures used to define the two ZOIs listed in (a) and (b), above, are based on Large Break
28 LOCA conditions. These are conservative as they envelop the coatings surface areas that would
29 be exposed to jetting from postulated Large and Small LOCAs. This results in the calculation of
30 a maximum volume of debris from DBA-qualified/Acceptable coatings which could potentially
31 be generated and used for post-accident sump performance evaluation.

32 REFERENCES

- 33 A-1. ANSI N101.2-1972, "Protective Coatings (Paints) for Light Water Nuclear Reactor
34 Containment Facilities" American National Standards Institute, Approved
35 May 30, 1972.

- 1 A-2. ASTM D 3911-95, "Standard Test Method for Evaluating Coatings Used in
2 Light-Water Nuclear Power Plants at Simulated Design Basis Accident (DBA)
3 Conditions" ASTM International, 1995.
- 4 A-3. U.S. Nuclear Regulatory Commission Regulatory Guide 1.54, "Service Level I, II,
5 and III Protective Coatings Applied to Nuclear Power Plants," Revision 1 (July 2000).
- 6 A-4. ASTM D 5144-00, "Standard Guide for Use of Protective Coating Standards in
7 Nuclear Power Plants" ASTM International, 2000.
- 8 A-5. WSRC-TR-2000-00340, "Degradation and Failure Characteristics of NPP
9 Containment Protective Coating Systems (U)," October 2000.
- 10 A-6. WSRC-TR-2001-00067, "Degradation and Failure Characteristics of NPP
11 Containment Protective Coating Systems (U) Interim Report No. 3," February 2001.

1

ATTACHMENT A

2

COATINGS PERFORMANCE 3500 PSI STEAM TEST

3

TEST PROGRAM AND TEST RESULTS

COATINGS PERFORMANCE 3500 PSI STEAM TEST
GENERAL NOTES

1. High pressure steam cleaner used: Cat Pump model 5CP3120G1 (4.5 gpm, 3,500 psig); 3,500 psig, 194 deg F water temperature
2. Water contact temperature at the surface being waterjetted was measured at 150 deg F using a contact pyrometer.
3. Fan pattern nozzle used, 0.15 in. diameter, 45 degree tip; At 12 in. standoff, fan major dimension 6 in., minor dimension 0.75 in.
4. Test runs were 1 minute in duration except as noted.
5. The surface preparation and coating application of the test samples were performed in accordance with the Florida Power and Light safety-related (Service Level 1) coating specification.
6. 90-degree angle of attack was more aggressive than the <45 degree angle of attack.
7. At a standoff distance of 1 in., all coatings were removed to substrate within several seconds.

INDIVIDUAL TEST RUN DATA SHEETS

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 1A

ANGLE OF ATTACK: 90 DEGREES

STAND-OFF DISTANCE: 12 in.

X-CUT IN COATING: NO

SUBSTRATE: CONCRETE

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: 2011-S / 890 / 890

DRY FILM THICKNESS (MILS):

1ST COAT: 10 - 35

2ND COAT: 4 - 7

3RD COAT: 4 - 7

CONDITION OF COATING BEFORE TEST:

VISUAL: sound film, no defects

MICROSCOPIC: small pinholes in topcoat, <0.1% of surface

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 77 deg F

DURING TEST: 95 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: erosion at small anomalies in coating

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 1B

ANGLE OF ATTACK: 90 DEGREES

STAND-OFF DISTANCE: 6 in.

X-CUT IN COATING: NO

SUBSTRATE: CONCRETE

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: 2011-S / 890 / 890

DRY FILM THICKNESS (MILS):

1ST COAT: 10 - 35

2ND COAT: 4 - 7

3RD COAT: 4 - 7

CONDITION OF COATING BEFORE TEST:

VISUAL: sound film, erosion at small anomalies in coating from 12 in. test, <0.1% of surface

MICROSCOPIC: erosion at small anomalies in coating

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 77 deg F

DURING TEST: 95 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: increased erosion

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 2A

ANGLE OF ATTACK: 90 DEGREES

STAND-OFF DISTANCE: 12 in.

X-CUT IN COATING: YES

SUBSTRATE: CONCRETE

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: 2011-S / 890 / 890

DRY FILM THICKNESS (MILS):

1ST COAT: 10 - 35

2ND COAT: 4 - 7

3RD COAT: 4 - 7

CONDITION OF COATING BEFORE TEST:

VISUAL: sound film, no defects

MICROSCOPIC: small pinholes in topcoat, <0.1% of surface

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 77 deg F

DURING TEST: 95 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: erosion at small anomalies in coating

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 2B

ANGLE OF ATTACK: 90 DEGREES

STAND-OFF DISTANCE: 6 in.

X-CUT IN COATING: YES

SUBSTRATE: CONCRETE

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: 2011-S / 890 / 890

DRY FILM THICKNESS (MILS):

1ST COAT: 10 - 35

2ND COAT: 4 - 7

3RD COAT: 4 - 7

CONDITION OF COATING BEFORE TEST:

VISUAL: sound film, no defects

MICROSCOPIC: small pinholes in topcoat, <0.1% of surface

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 77 deg F

DURING TEST: 95 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: erosion at small anomalies in coating, slight erosion at scribe

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 3A

ANGLE OF ATTACK: <45 DEGREES

STAND-OFF DISTANCE: 12 in.

X-CUT IN COATING: NO

SUBSTRATE: CONCRETE

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: 2011-S / 890 / 890

DRY FILM THICKNESS (MILS):

1ST COAT: 10 - 35

2ND COAT: 4 - 7

3RD COAT: 4 - 7

CONDITION OF COATING BEFORE TEST:

VISUAL: sound film, no defects

MICROSCOPIC: small pinholes in topcoat, <0.1% of surface

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 77 deg F

DURING TEST: 95 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: erosion at small anomalies in coating

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 3B

4 **ANGLE OF ATTACK:** <45 DEGREES

5 **STAND-OFF DISTANCE:** 6 in.

6 **X-CUT IN COATING:** NO

7 **SUBSTRATE:** CONCRETE

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** 2011-S / 890 / 890

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 10 - 35

12 2ND COAT: 4 - 7

13 3RD COAT: 4 - 7

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: sound film, erosion at small anomalies in coating from 12 in. test, <0.1% of surface

16 MICROSCOPIC: erosion at small anomalies in coating

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 77 deg F

19 DURING TEST: 95 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: ½ in. dia loss of coating

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 3C

4 **ANGLE OF ATTACK:** <45 DEGREES

5 **STAND-OFF DISTANCE:** 3 in.

6 **X-CUT IN COATING:** NO

7 **SUBSTRATE:** CONCRETE

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** 2011-S / 890 / 890

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 10 - 35

12 2ND COAT: 4 - 7

13 3RD COAT: 4 - 7

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: sound film, erosion at small anomalies in coating from 6 in. test, <0.1% of surface

16 MICROSCOPIC: erosion at small anomalies in coating

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 77 deg F

19 DURING TEST: 95 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: erosion failure of coating to substrate at anomalies, 1/16 in. dia

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 4A

ANGLE OF ATTACK: <45 DEGREES

STAND-OFF DISTANCE: 12 in.

X-CUT IN COATING: YES

SUBSTRATE: CONCRETE

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: 2011-S / 890 / 890

DRY FILM THICKNESS (MILS):

1ST COAT: 10 - 35

2ND COAT: 4 - 7

3RD COAT: 4 - 7

CONDITION OF COATING BEFORE TEST:

VISUAL: sound film, no defects

MICROSCOPIC: small pinholes in topcoat, <0.1% of surface

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 77 deg F

DURING TEST: 95 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: erosion at small anomalies in coating

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 4B

4 **ANGLE OF ATTACK:** <45 DEGREES

5 **STAND-OFF DISTANCE:** 6 in.

6 **X-CUT IN COATING:** NO

7 **SUBSTRATE:** CONCRETE

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** 2011-S / 890 / 890

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 10 - 35

12 2ND COAT: 4 - 7

13 3RD COAT: 4 - 7

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: sound film, erosion at small anomalies in coating from 12 in. test, <0.1% of surface

16 MICROSCOPIC: erosion at small anomalies in coating

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 77 deg F

19 DURING TEST: 95 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: 1 in. loss of coating system along scribe line

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

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None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 5A

ANGLE OF ATTACK: 90 DEGREES

STAND-OFF DISTANCE: 12 in.

X-CUT IN COATING: NO

SUBSTRATE: CONCRETE

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: 890 / 890

DRY FILM THICKNESS (MILS):

1ST COAT: 4 - 7

2ND COAT: 4 - 7

3RD COAT: n/a

CONDITION OF COATING BEFORE TEST:

VISUAL: sound film, no defects

MICROSCOPIC: sound film

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 81 deg F

DURING TEST: 95 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: sound film, no defects

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 5B

ANGLE OF ATTACK: 90 DEGREES

STAND-OFF DISTANCE: 6 in.

X-CUT IN COATING: NO

SUBSTRATE: CONCRETE

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: 890 / 890

DRY FILM THICKNESS (MILS):

1ST COAT: 4 - 7

2ND COAT: 4 - 7

3RD COAT: n/a

CONDITION OF COATING BEFORE TEST:

VISUAL: sound film, no defects

MICROSCOPIC: sound film, no defects

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 81 deg F

DURING TEST: 95 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: significant coating removal approximately ½ in dia

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 6A

4 **ANGLE OF ATTACK:** <45 DEGREES

5 **STAND-OFF DISTANCE:** 12 in.

6 **X-CUT IN COATING:** YES

7 **SUBSTRATE:** CONCRETE

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** 890 / 890

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 4 - 7

12 2ND COAT: 4 - 7

13 3RD COAT: n/a

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: sound film, no defects

16 MICROSCOPIC: sound film

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 81 deg F

19 DURING TEST: 95 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: slight erosion at scribe

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 6B

ANGLE OF ATTACK: <45 DEGREES

STAND-OFF DISTANCE: 6 in.

X-CUT IN COATING: YES

SUBSTRATE: CONCRETE

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: 2011-S / 890 / 890

DRY FILM THICKNESS (MILS):

1ST COAT: 4 - 7

2ND COAT: 4 - 7

3RD COAT: n/a

CONDITION OF COATING BEFORE TEST:

VISUAL: sound film, no defects

MICROSCOPIC: sound film, no defects

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 81 deg F

DURING TEST: 95 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: significant coating removal along scribe, ½ in. by ¼ in.

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 7A

4 **ANGLE OF ATTACK:** 90 DEGREES

5 **STAND-OFF DISTANCE:** 12 in.

6 **X-CUT IN COATING:** NO

7 **SUBSTRATE:** STEEL

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** 890 / 890

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 4 - 7

12 2ND COAT: 4 - 7

13 3RD COAT: n/a

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: sound film, no defects

16 MICROSCOPIC: sound film

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 81 deg F

19 DURING TEST: 95 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: sound film, no defects

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 7B

4 **ANGLE OF ATTACK:** 90 DEGREES

5 **STAND-OFF DISTANCE:** 6 in.

6 **X-CUT IN COATING:** NO

7 **SUBSTRATE:** STEEL

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** 890 / 890

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 4 - 7

12 2ND COAT: 4 - 7

13 3RD COAT: n/a

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: sound film, no defects

16 MICROSCOPIC: sound film

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 81 deg F

19 DURING TEST: 95 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: sound film, no defects

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 8A

ANGLE OF ATTACK: <45 DEGREES

STAND-OFF DISTANCE: 12 in.

X-CUT IN COATING: YES

SUBSTRATE: STEEL

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: 890 / 890

DRY FILM THICKNESS (MILS):

1ST COAT: 4 - 7

2ND COAT: 4 - 7

3RD COAT: n/a

CONDITION OF COATING BEFORE TEST:

VISUAL: sound film, no defects

MICROSCOPIC: sound film

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 81 deg F

DURING TEST: 95 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: slight erosion at scribe

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 8B

4 **ANGLE OF ATTACK:** <45 DEGREES

5 **STAND-OFF DISTANCE:** 6 in.

6 **X-CUT IN COATING:** YES

7 **SUBSTRATE:** STEEL

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** 890 / 890

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 4 - 7

12 2ND COAT: 4 - 7

13 3RD COAT: n/a

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: slight erosion at scribe

16 MICROSCOPIC: slight erosion at scribe

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 81 deg F

19 DURING TEST: 95 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: minor (1/16 in dia) coating loss

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 9A

ANGLE OF ATTACK: 90 DEGREES

STAND-OFF DISTANCE: 12 in.

X-CUT IN COATING: NO

SUBSTRATE: STEEL

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: CZ-11 SG / 890 / 890

DRY FILM THICKNESS (MILS):

1ST COAT: 1.5 – 2.5

2ND COAT: 4 - 7

3RD COAT: 4 -7

CONDITION OF COATING BEFORE TEST:

VISUAL: sound film, brush marks in topcoat

MICROSCOPIC: small pinholes in topcoat

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 84 deg F

DURING TEST: 102 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: sound film, no defects

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 9B

ANGLE OF ATTACK: 90 DEGREES

STAND-OFF DISTANCE: 6 in.

X-CUT IN COATING: NO

SUBSTRATE: STEEL

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: CZ-11 SG / 890 / 890

DRY FILM THICKNESS (MILS):

1ST COAT: 1.5 – 2.5

2ND COAT: 4 - 7

3RD COAT: 4 - 7

CONDITION OF COATING BEFORE TEST:

VISUAL: sound film, brush marks in topcoat

MICROSCOPIC: small pinholes in topcoat

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 84 deg F

DURING TEST: 102 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: onset of coating failure to substrate by erosion, 1/8 in. dia

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 9C

ANGLE OF ATTACK: 90 DEGREES

STAND-OFF DISTANCE: 3 in.

X-CUT IN COATING: NO

SUBSTRATE: STEEL

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: CZ-11 SG / 890 / 890

DRY FILM THICKNESS (MILS):

1ST COAT: 1.5 – 2.5

2ND COAT: 4 - 7

3RD COAT: 4 -7

CONDITION OF COATING BEFORE TEST:

VISUAL: onset of coating failure to substrate by erosion

MICROSCOPIC:

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 84 deg F

DURING TEST: 102 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: extensive coating failure to substrate by erosion in 30 seconds, 1 in. by 2 in.

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 10A

ANGLE OF ATTACK: 90 DEGREES

STAND-OFF DISTANCE: 12 in.

X-CUT IN COATING: YES

SUBSTRATE: STEEL

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: CZ-11 SG / 890 / 890

DRY FILM THICKNESS (MILS):

1ST COAT: 1.5 – 2.5

2ND COAT: 4 - 7

3RD COAT: 4 -7

CONDITION OF COATING BEFORE TEST:

VISUAL: sound film, brush marks in topcoat

MICROSCOPIC: small pinholes in topcoat

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 84 deg F

DURING TEST: 102 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: sound film, no defects

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 10B

4 **ANGLE OF ATTACK:** 90 DEGREES

5 **STAND-OFF DISTANCE:** 6 in.

6 **X-CUT IN COATING:** YES

7 **SUBSTRATE:** STEEL

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** CZ-11 SG / 890 / 890

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 1.5 – 2.5

12 2ND COAT: 4 - 7

13 3RD COAT: 4 -7

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: sound film, brush marks in topcoat

16 MICROSCOPIC: small pinholes in topcoat

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 84 deg F

19 DURING TEST: 102 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: onset of coating failure to substrate by erosion along scribe line, 1/8 in. by 1-1/2 in.

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 10C

4 **ANGLE OF ATTACK:** 90 DEGREES

5 **STAND-OFF DISTANCE:** 3 in.

6 **X-CUT IN COATING:** YES

7 **SUBSTRATE:** STEEL

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** CZ-11 SG / 890 / 890

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 1.5 – 2.5

12 2ND COAT: 4 - 7

13 3RD COAT: 4 -7

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: onset of coating failure to substrate by erosion

16 MICROSCOPIC:

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 84 deg F

19 DURING TEST: 102 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: extensive coating failure to substrate by erosion in 30 seconds, 1 in. by 1 in.

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 11A

4 **ANGLE OF ATTACK:** <45 DEGREES

5 **STAND-OFF DISTANCE:** 12 in.

6 **X-CUT IN COATING:** NO

7 **SUBSTRATE:** STEEL

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** CZ-11 SG / 890 / 890

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 1.5 – 2.5

12 2ND COAT: 4 - 7

13 3RD COAT: 4 -7

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: sound film, brush marks in topcoat

16 MICROSCOPIC: small pinholes in topcoat

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 84 deg F

19 DURING TEST: 102 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: sound film, no defects

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 11B

ANGLE OF ATTACK: <45 DEGREES

STAND-OFF DISTANCE: 6 in.

X-CUT IN COATING: NO

SUBSTRATE: STEEL

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: CZ-11 SG / 890 / 890

DRY FILM THICKNESS (MILS):

1ST COAT: 1.5 – 2.5

2ND COAT: 4 - 7

3RD COAT: 4 -7

CONDITION OF COATING BEFORE TEST:

VISUAL: sound film, brush marks in topcoat

MICROSCOPIC: small pinholes in topcoat

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 84 deg F

DURING TEST: 102 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: onset of coating failure to substrate by erosion of topcoat

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 11C

ANGLE OF ATTACK: <45 DEGREES

STAND-OFF DISTANCE: 3 in.

X-CUT IN COATING: NO

SUBSTRATE: STEEL

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: CZ-11 SG / 890 / 890

DRY FILM THICKNESS (MILS):

1ST COAT: 1.5 – 2.5

2ND COAT: 4 - 7

3RD COAT: 4 - 7

CONDITION OF COATING BEFORE TEST:

VISUAL: onset of coating failure to substrate by erosion

MICROSCOPIC:

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 84 deg F

DURING TEST: 102 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: extensive coating failure to substrate by erosion in 30 seconds, 1 in. by 1 in.

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 12A

4 **ANGLE OF ATTACK:** <45 DEGREES

5 **STAND-OFF DISTANCE:** 12 in.

6 **X-CUT IN COATING:** YES

7 **SUBSTRATE:** STEEL

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** CZ-11 SG / 890 / 890

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 1.5 – 2.5

12 2ND COAT: 4 - 7

13 3RD COAT: 4 -7

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: sound film, brush marks in topcoat

16 MICROSCOPIC: small pinholes in topcoat

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 84 deg F

19 DURING TEST: 102 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: sound film, no defects

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 12B

ANGLE OF ATTACK: <45 DEGREES

STAND-OFF DISTANCE: 6 in.

X-CUT IN COATING: YES

SUBSTRATE: STEEL

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: CZ-11 SG / 890 / 890

DRY FILM THICKNESS (MILS):

1ST COAT: 1.5 – 2.5

2ND COAT: 4 - 7

3RD COAT: 4 -7

CONDITION OF COATING BEFORE TEST:

VISUAL: sound film, brush marks in topcoat

MICROSCOPIC: small pinholes in topcoat

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 84 deg F

DURING TEST: 102 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: onset of coating failure to substrate by erosion along scribe line, 1/32 in. by 2-1/2 in.

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 12C

4 **ANGLE OF ATTACK:** <45 DEGREES

5 **STAND-OFF DISTANCE:** 3 in.

6 **X-CUT IN COATING:** YES

7 **SUBSTRATE:** STEEL

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** CZ-11 SG / 890 / 890

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 1.5 – 2.5

12 2ND COAT: 4 - 7

13 3RD COAT: 4 -7

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: onset of coating failure to substrate by erosion

16 MICROSCOPIC:

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 84 deg F

19 DURING TEST: 102 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: extensive coating failure to substrate by erosion in 30 seconds, 1 in. by 1 in.

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 13A

4 **ANGLE OF ATTACK:** 90 DEGREES

5 **STAND-OFF DISTANCE:** 12 in.

6 **X-CUT IN COATING:** NO

7 **SUBSTRATE:** STEEL

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** 890 / 890

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 4 - 7

12 2ND COAT: 4 - 7

13 3RD COAT: n/a

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: sound film, no defects

16 MICROSCOPIC: light dry spray

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 79 deg F

19 DURING TEST: 102 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: sound film, no defects

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 13B

4 **ANGLE OF ATTACK:** 90 DEGREES

5 **STAND-OFF DISTANCE:** 6 in.

6 **X-CUT IN COATING:** NO

7 **SUBSTRATE:** STEEL

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** 890 / 890

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 4 - 7

12 2ND COAT: 4 - 7

13 3RD COAT: n/a

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: sound film, no defects

16 MICROSCOPIC: light dry spray

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 79 deg F

19 DURING TEST: 102 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: sound film, no defects

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 14A

4 **ANGLE OF ATTACK:** 90 DEGREES

5 **STAND-OFF DISTANCE:** 12 in.

6 **X-CUT IN COATING:** YES

7 **SUBSTRATE:** STEEL

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** 890 / 890

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 4 - 7

12 2ND COAT: 4 - 7

13 3RD COAT: n/a

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: sound film, no defects

16 MICROSCOPIC: light dry spray

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 79 deg F

19 DURING TEST: 102 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: sound film, no defects

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 14B

4 **ANGLE OF ATTACK:** 90 DEGREES

5 **STAND-OFF DISTANCE:** 6 in.

6 **X-CUT IN COATING:** YES

7 **SUBSTRATE:** STEEL

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** 890 / 890

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 4 - 7

12 2ND COAT: 4 - 7

13 3RD COAT: n/a

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: sound film, no defects

16 MICROSCOPIC: light dry spray

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 79 deg F

19 DURING TEST: 102 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: slight coating erosion at scribe

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 15A

4 **ANGLE OF ATTACK:** <45 DEGREES

5 **STAND-OFF DISTANCE:** 12 in.

6 **X-CUT IN COATING:** NO

7 **SUBSTRATE:** STEEL

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** 890 / 890

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 4 - 7

12 2ND COAT: 4 - 7

13 3RD COAT: n/a

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: sound film, no defects

16 MICROSCOPIC: light dry spray

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 79 deg F

19 DURING TEST: 102 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: sound film, no defects

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 15B

4 **ANGLE OF ATTACK:** <45 DEGREES

5 **STAND-OFF DISTANCE:** 6 in.

6 **X-CUT IN COATING:** NO

7 **SUBSTRATE:** STEEL

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** 890 / 890

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 4 - 7

12 2ND COAT: 4 - 7

13 3RD COAT: n/a

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: sound film, no defects

16 MICROSCOPIC: light dry spray

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 79 deg F

19 DURING TEST: 102 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: sound film, no defects

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 16A

4 **ANGLE OF ATTACK:** <45 DEGREES

5 **STAND-OFF DISTANCE:** 12 in.

6 **X-CUT IN COATING:** YES

7 **SUBSTRATE:** STEEL

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** 890 / 890

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 4 - 7

12 2ND COAT: 4 - 7

13 3RD COAT: n/a

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: sound film, no defects

16 MICROSCOPIC: light dry spray

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 79 deg F

19 DURING TEST: 102 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: sound film, no defects

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 16B

4 **ANGLE OF ATTACK:** <45 DEGREES

5 **STAND-OFF DISTANCE:** 6 in.

6 **X-CUT IN COATING:** YES

7 **SUBSTRATE:** STEEL

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** 890 / 890

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 4 - 7

12 2ND COAT: 4 - 7

13 3RD COAT: n/a

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: sound film, no defects

16 MICROSCOPIC: light dry spray

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 79 deg F

19 DURING TEST: 102 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: slight coating erosion at scribe

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

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COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 17A

ANGLE OF ATTACK: 90 DEGREES

STAND-OFF DISTANCE: 18 in.

X-CUT IN COATING: NO

SUBSTRATE: STEEL

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: CZ 11 SG

DRY FILM THICKNESS (MILS):

1ST COAT: 1.5 – 2.5

2ND COAT: n/a

3RD COAT: n/a

CONDITION OF COATING BEFORE TEST:

VISUAL: sound film, no defects

MICROSCOPIC: no defects

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 87 deg F

DURING TEST: 102 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: loss of ½ thickness (~1 mil) in 1 minute

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 17B

ANGLE OF ATTACK: 90 DEGREES

STAND-OFF DISTANCE: 12 in.

X-CUT IN COATING: NO

SUBSTRATE: STEEL

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: CZ 11 SG

DRY FILM THICKNESS (MILS):

1ST COAT: 1.5 – 2.5

2ND COAT: n/a

3RD COAT: n/a

CONDITION OF COATING BEFORE TEST:

VISUAL: film eroded by previous test

MICROSCOPIC: erosion damage evident

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 87 deg F

DURING TEST: 102 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: loss of ½ thickness (~1 mil) in 1 minute

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 17C

ANGLE OF ATTACK: 90 DEGREES

STAND-OFF DISTANCE: 6 in.

X-CUT IN COATING: NO

SUBSTRATE: STEEL

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: CZ 11 SG

DRY FILM THICKNESS (MILS):

1ST COAT: 1.5 – 2.5

2ND COAT: n/a

3RD COAT: n/a

CONDITION OF COATING BEFORE TEST:

VISUAL: film eroded by previous test

MICROSCOPIC: erosion damage evident

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 87 deg F

DURING TEST: 102 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: total loss of coating to substrate

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 17D

ANGLE OF ATTACK: 90 DEGREES

STAND-OFF DISTANCE: 3 in.

X-CUT IN COATING: NO

SUBSTRATE: STEEL

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: CZ 11 SG

DRY FILM THICKNESS (MILS):

1ST COAT: 1.5 – 2.5

2ND COAT: n/a

3RD COAT: n/a

CONDITION OF COATING BEFORE TEST:

VISUAL: film eroded by previous test

MICROSCOPIC: erosion damage evident

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 87 deg F

DURING TEST: 102 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: complete failure to substrate in ~10 seconds, 1 in. by 2 in.

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 17E

4 **ANGLE OF ATTACK:** 90 DEGREES

5 **STAND-OFF DISTANCE:** 21 in.

6 **X-CUT IN COATING:** NO

7 **SUBSTRATE:** STEEL

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** CZ 11 SG

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 1.5 – 2.5

12 2ND COAT: n/a

13 3RD COAT: n/a

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: sound film, no defects

16 MICROSCOPIC: no defects

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 87 deg F

19 DURING TEST: 102 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: no change; no loss of coating thickness

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 18A

4 **ANGLE OF ATTACK:** 90 DEGREES

5 **STAND-OFF DISTANCE:** 18 in.

6 **X-CUT IN COATING:** YES

7 **SUBSTRATE:** STEEL

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** CZ 11 SG

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 1.5 – 2.5

12 2ND COAT: n/a

13 3RD COAT: n/a

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: sound film, no defects

16 MICROSCOPIC: no defects

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 87 deg F

19 DURING TEST: 102 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: loss of ½ thickness (~1 mil) in 1 minute

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 18B

ANGLE OF ATTACK: 90 DEGREES

STAND-OFF DISTANCE: 12 in.

X-CUT IN COATING: YES

SUBSTRATE: STEEL

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: CZ 11 SG

DRY FILM THICKNESS (MILS):

1ST COAT: 1.5 – 2.5

2ND COAT: n/a

3RD COAT: n/a

CONDITION OF COATING BEFORE TEST:

VISUAL: film eroded by previous test

MICROSCOPIC: erosion damage evident

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 87 deg F

DURING TEST: 102 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: loss of ½ thickness (~1 mil) in 1 minute

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 18C

4 **ANGLE OF ATTACK:** 90 DEGREES

5 **STAND-OFF DISTANCE:** 6 in.

6 **X-CUT IN COATING:** YES

7 **SUBSTRATE:** STEEL

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** CZ 11 SG

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 1.5 – 2.5

12 2ND COAT: n/a

13 3RD COAT: n/a

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: film eroded by previous test

16 MICROSCOPIC: erosion damage evident

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 87 deg F

19 DURING TEST: 102 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: total loss of coating to substrate

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 18D

ANGLE OF ATTACK: 90 DEGREES

STAND-OFF DISTANCE: 3 in.

X-CUT IN COATING: YES

SUBSTRATE: STEEL

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: CZ 11 SG

DRY FILM THICKNESS (MILS):

1ST COAT: 1.5 – 2.5

2ND COAT: n/a

3RD COAT: n/a

CONDITION OF COATING BEFORE TEST:

VISUAL: film eroded by previous test

MICROSCOPIC: erosion damage evident

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 87 deg F

DURING TEST: 102 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: complete failure to substrate in ~10 seconds, 1 in. by 2 in.

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 19A

ANGLE OF ATTACK: <45 DEGREES

STAND-OFF DISTANCE: 12 in.

X-CUT IN COATING: NO

SUBSTRATE: STEEL

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: CZ 11 SG

DRY FILM THICKNESS (MILS):

1ST COAT: 1.5 – 2.5

2ND COAT: n/a

3RD COAT: n/a

CONDITION OF COATING BEFORE TEST:

VISUAL: coating film sound

MICROSCOPIC: coating film sound

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 87 deg F

DURING TEST: 102 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: slight coating erosion

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 19B

ANGLE OF ATTACK: <45 DEGREES

STAND-OFF DISTANCE: 6 in.

X-CUT IN COATING: NO

SUBSTRATE: STEEL

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: CZ 11 SG

DRY FILM THICKNESS (MILS):

1ST COAT: 1.5 – 2.5

2ND COAT: n/a

3RD COAT: n/a

CONDITION OF COATING BEFORE TEST:

VISUAL: film eroded by previous test

MICROSCOPIC: erosion damage evident

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 87 deg F

DURING TEST: 102 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: total loss of coating to substrate in 30 seconds

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 19C

ANGLE OF ATTACK: <45 DEGREES

STAND-OFF DISTANCE: 3 in.

X-CUT IN COATING: NO

SUBSTRATE: STEEL

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: CZ 11 SG

DRY FILM THICKNESS (MILS):

1ST COAT: 1.5 – 2.5

2ND COAT: n/a

3RD COAT: n/a

CONDITION OF COATING BEFORE TEST:

VISUAL: film eroded by previous test

MICROSCOPIC: erosion damage evident

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 87 deg F

DURING TEST: 102 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: complete failure to substrate in ~10 seconds, 1 in. by 2 in.

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 20A

4 **ANGLE OF ATTACK:** <45 DEGREES

5 **STAND-OFF DISTANCE:** 12 in.

6 **X-CUT IN COATING:** YES

7 **SUBSTRATE:** STEEL

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** CZ 11 SG

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 1.5 – 2.5

12 2ND COAT: n/a

13 3RD COAT: n/a

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: coating film sound

16 MICROSCOPIC: coating film sound

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 87 deg F

19 DURING TEST: 102 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: slight coating erosion

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

1 COATINGS PERFORMANCE 3500 PSI STEAM TEST

2 **DATE:** April 8, 2004

3 **Sample No.:** 20B

4 **ANGLE OF ATTACK:** <45 DEGREES

5 **STAND-OFF DISTANCE:** 6 in.

6 **X-CUT IN COATING:** YES

7 **SUBSTRATE:** STEEL

8 **SURFACE PREPARATION:** abrasive blast

9 **COATING SYSTEM:** CZ 11 SG

10 **DRY FILM THICKNESS (MILS):**

11 1ST COAT: 1.5 – 2.5

12 2ND COAT: n/a

13 3RD COAT: n/a

14 **CONDITION OF COATING BEFORE TEST:**

15 VISUAL: film eroded by previous test

16 MICROSCOPIC: erosion damage evident

17 **SUBSTRATE TEMPERATURE READINGS:**

18 BEFORE TEST: 87 deg F

19 DURING TEST: 102 deg F

20 **CONDITION OF COATING AFTER TEST:**

21 VISUAL: total loss of coating to substrate in 30 seconds

22 **DESCRIPTION OF COATING DEBRIS GENERATED:**

23 None visible

COATINGS PERFORMANCE 3500 PSI STEAM TEST

DATE: April 8, 2004

Sample No.: 20C

ANGLE OF ATTACK: <45 DEGREES

STAND-OFF DISTANCE: 3 in.

X-CUT IN COATING: YES

SUBSTRATE: STEEL

SURFACE PREPARATION: abrasive blast

COATING SYSTEM: CZ 11 SG

DRY FILM THICKNESS (MILS):

1ST COAT: 1.5 – 2.5

2ND COAT: n/a

3RD COAT: n/a

CONDITION OF COATING BEFORE TEST:

VISUAL: film eroded by previous test

MICROSCOPIC: erosion damage evident

SUBSTRATE TEMPERATURE READINGS:

BEFORE TEST: 87 deg F

DURING TEST: 102 deg F

CONDITION OF COATING AFTER TEST:

VISUAL: total loss of coating to substrate in ~10 seconds

DESCRIPTION OF COATING DEBRIS GENERATED:

None visible

TEST RUN PHOTOGRAPHS



Figure A-1. 3,500 psig Steam Power Washer



Figure A-2. 3,500 psig Steam Power Washer



Figure A-3. Scribing a Test Area



Figure A-4. Waterjet Operator



Figure A-5. Waterjetting



Figure A-6. Test Areas 9 – 20



Figure A-7. Test Areas 1 – 8

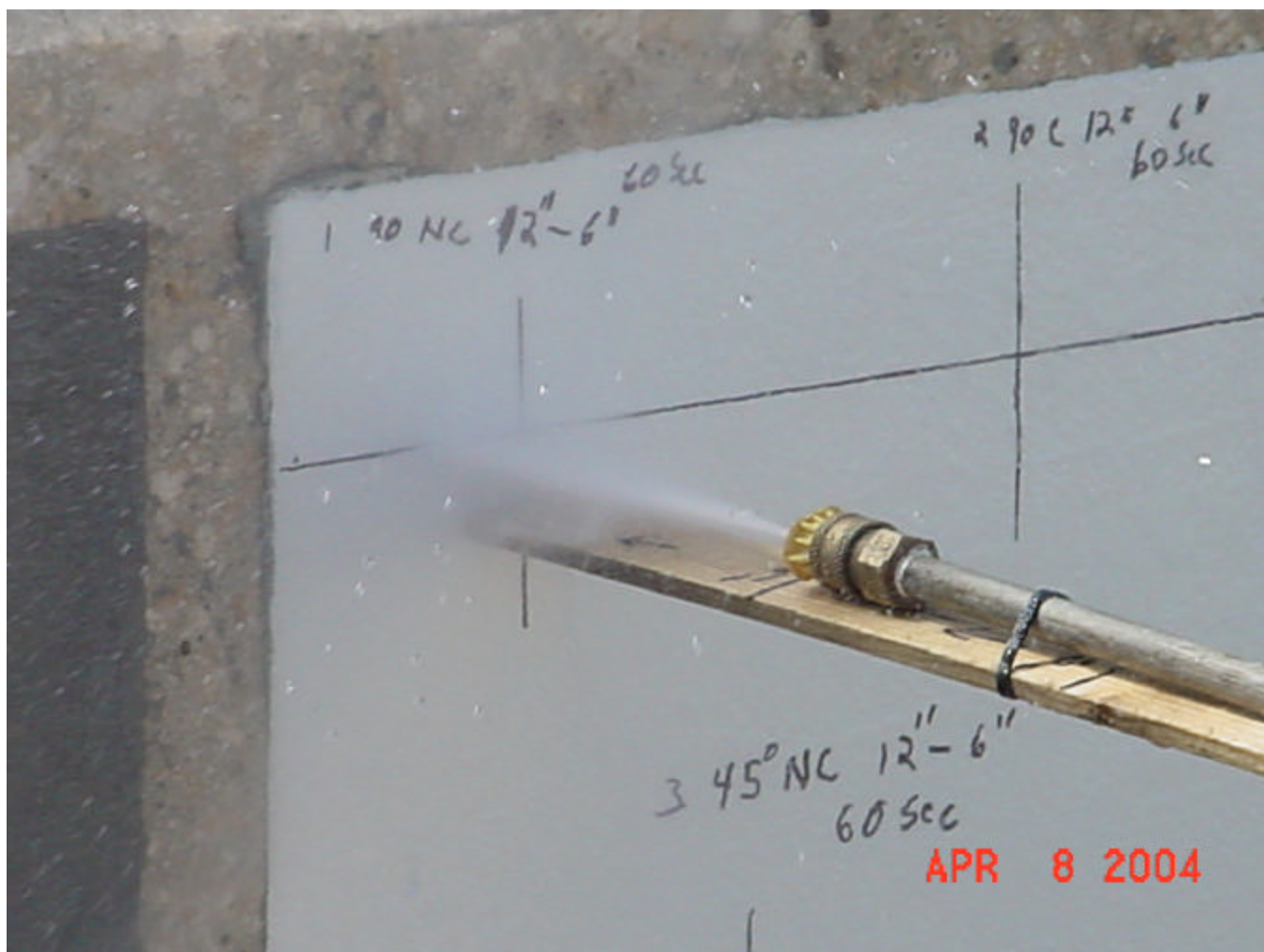


Figure A-8. Test Area 1, 6 in. Standoff

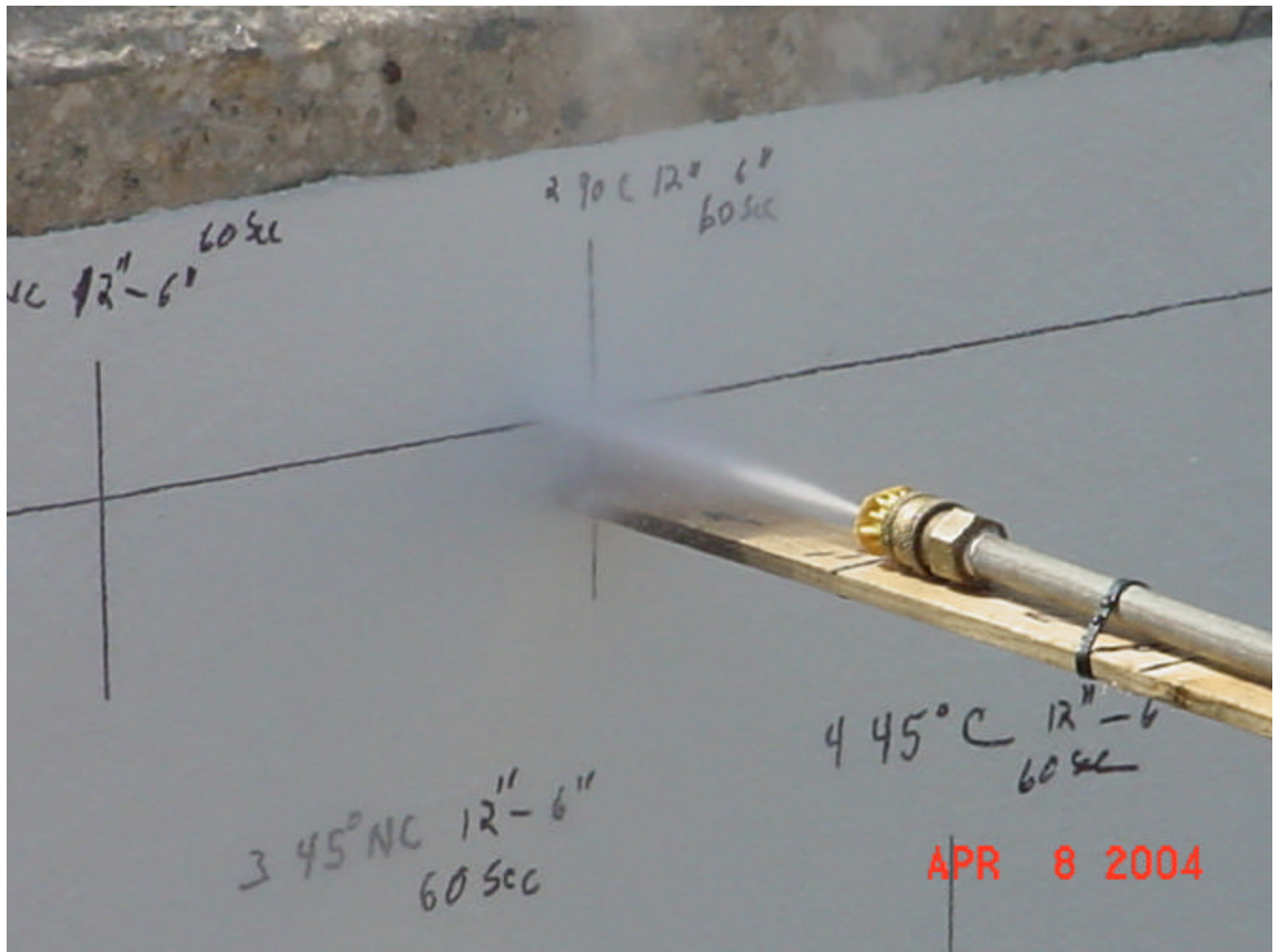


Figure A-9. Test Area 2, 6 in. Standoff

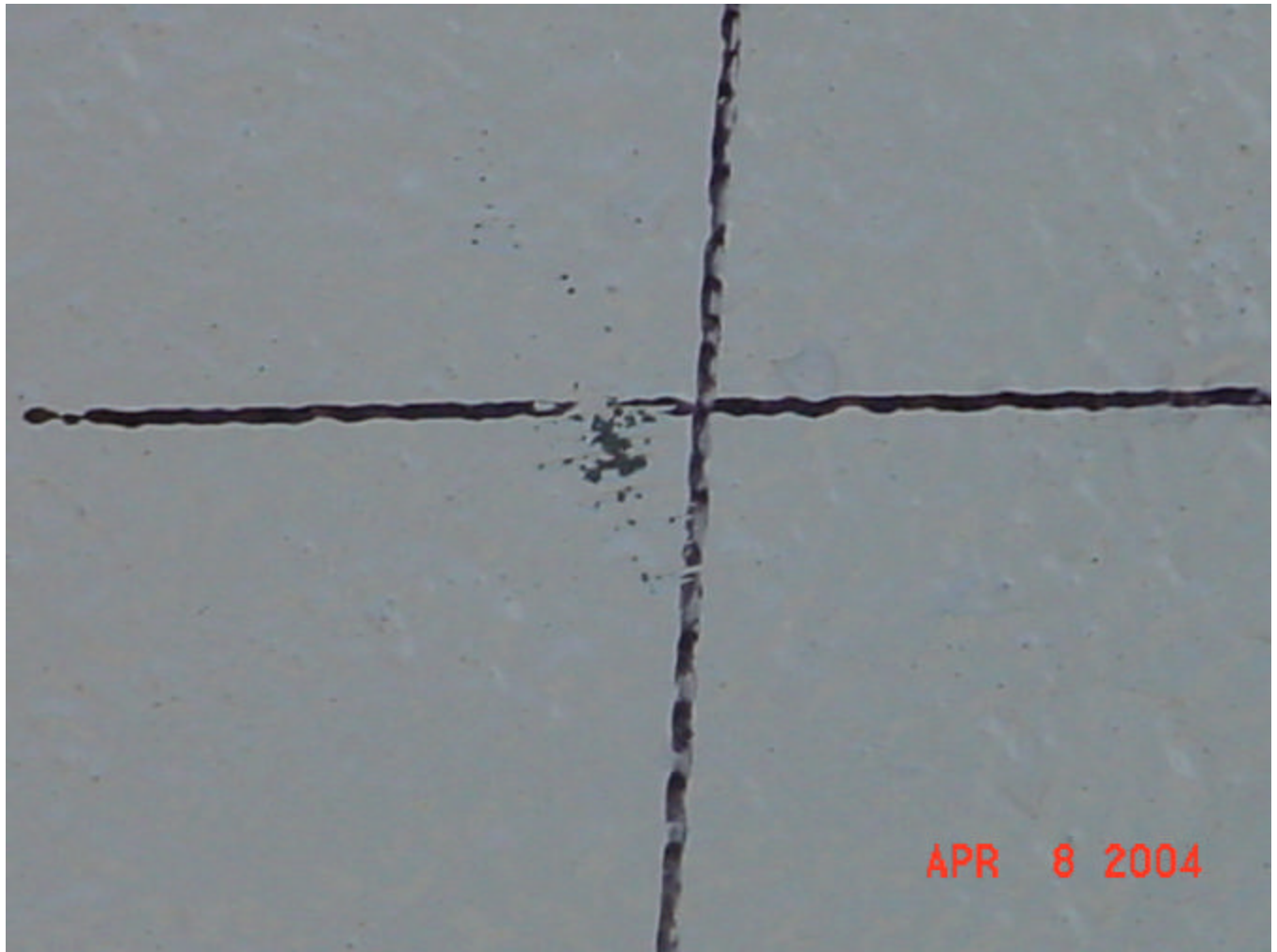


Figure A-10. Test Area 3, After 3 in. Standoff

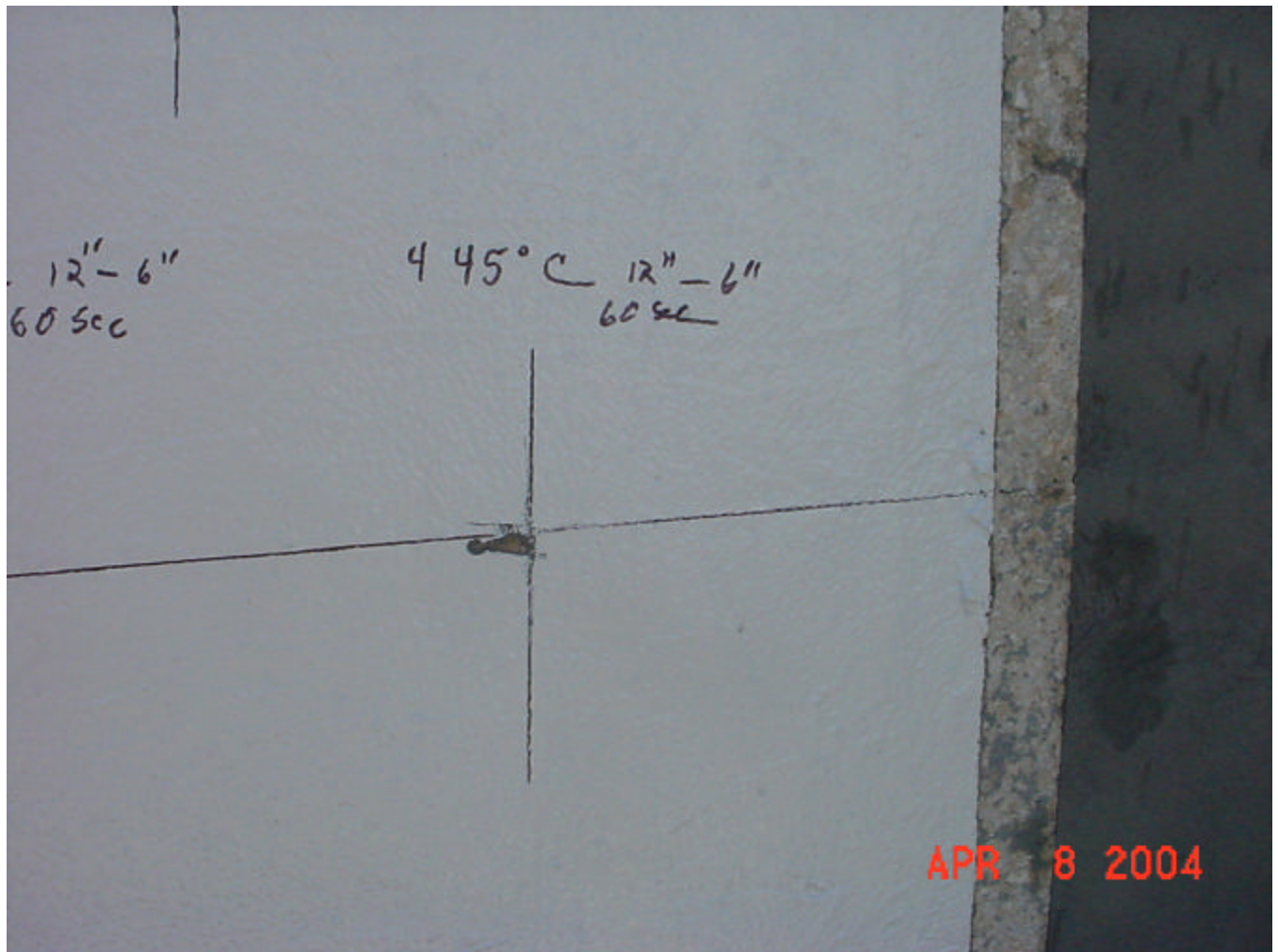


Figure A-11. Test Area 4, After 3 in. Standoff



Figure A-12. Test Area 4, After 3 in. Standoff (Closeup)



Figure A-13. Test Area 5, After 6 in. Standoff

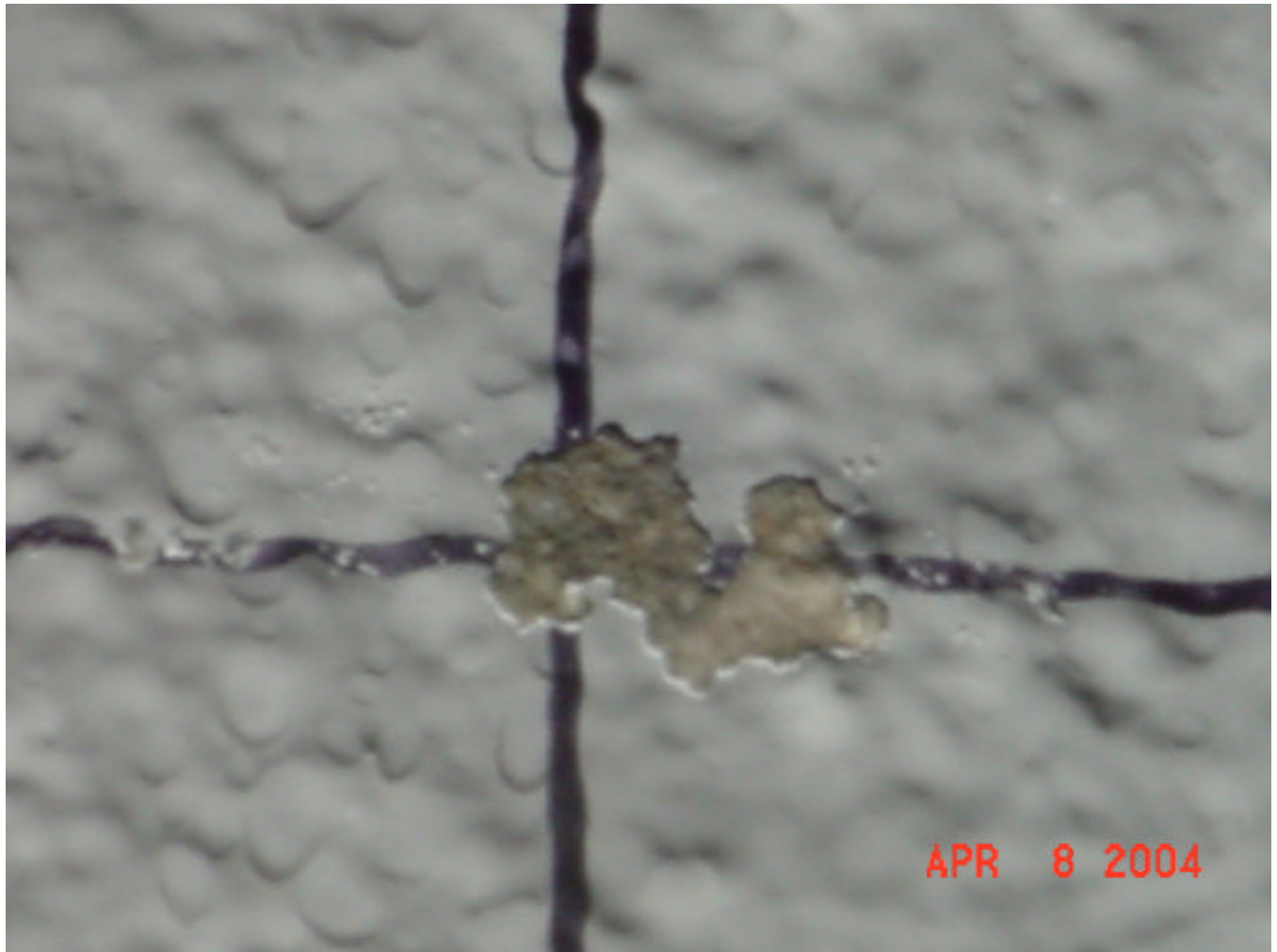


Figure A-14. Test Area 5, After 6 in. Standoff (Closeup)



Figure A-15. Test Area 6, After 6 in. Standoff



Figure A-16. Test Area 6, After 6 in. Standoff (Closeup)

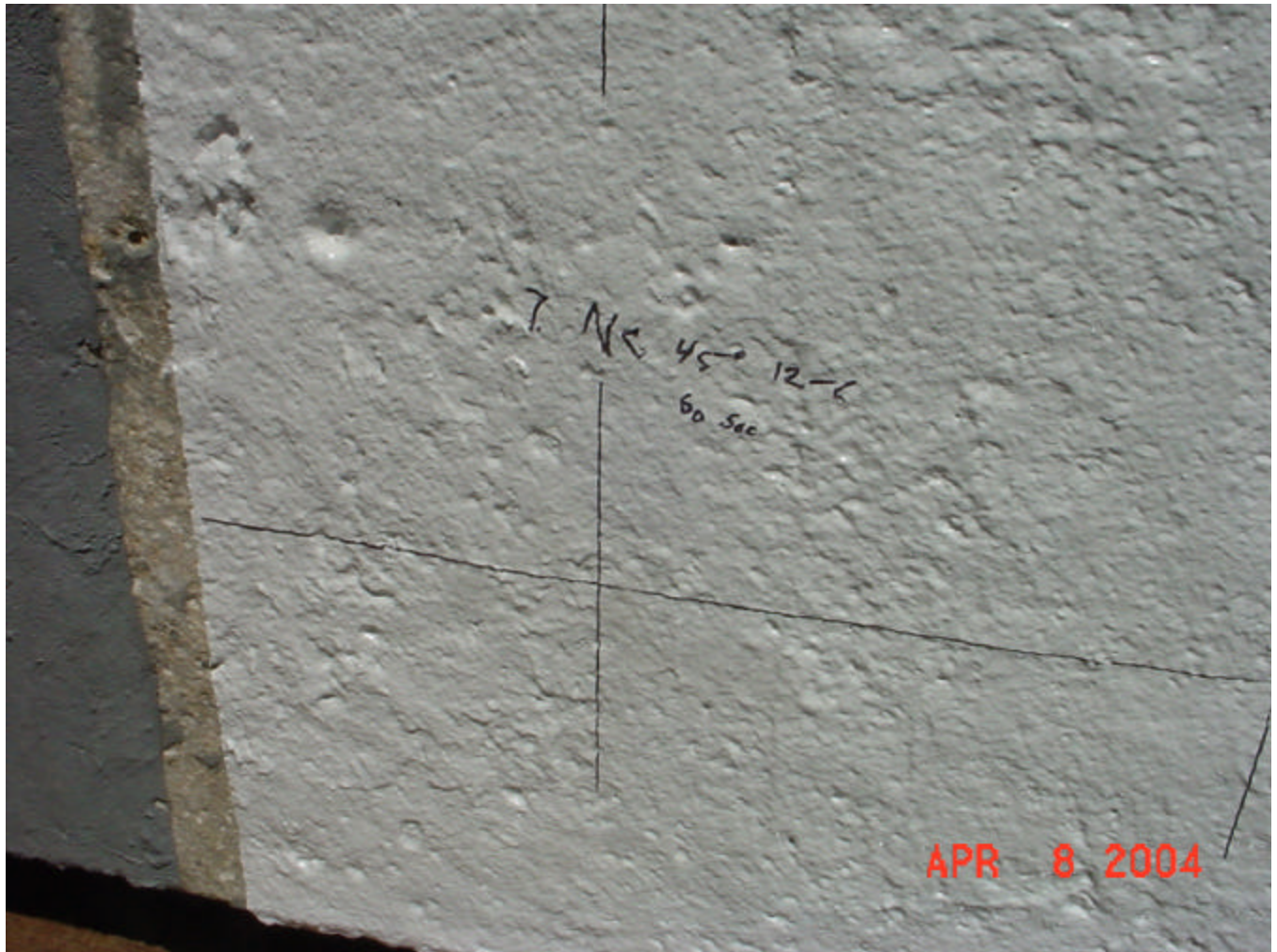


Figure A-17. Test Area 7, After 6 in. Standoff



Figure A-18. Test Area 8, After 6 in. Standoff

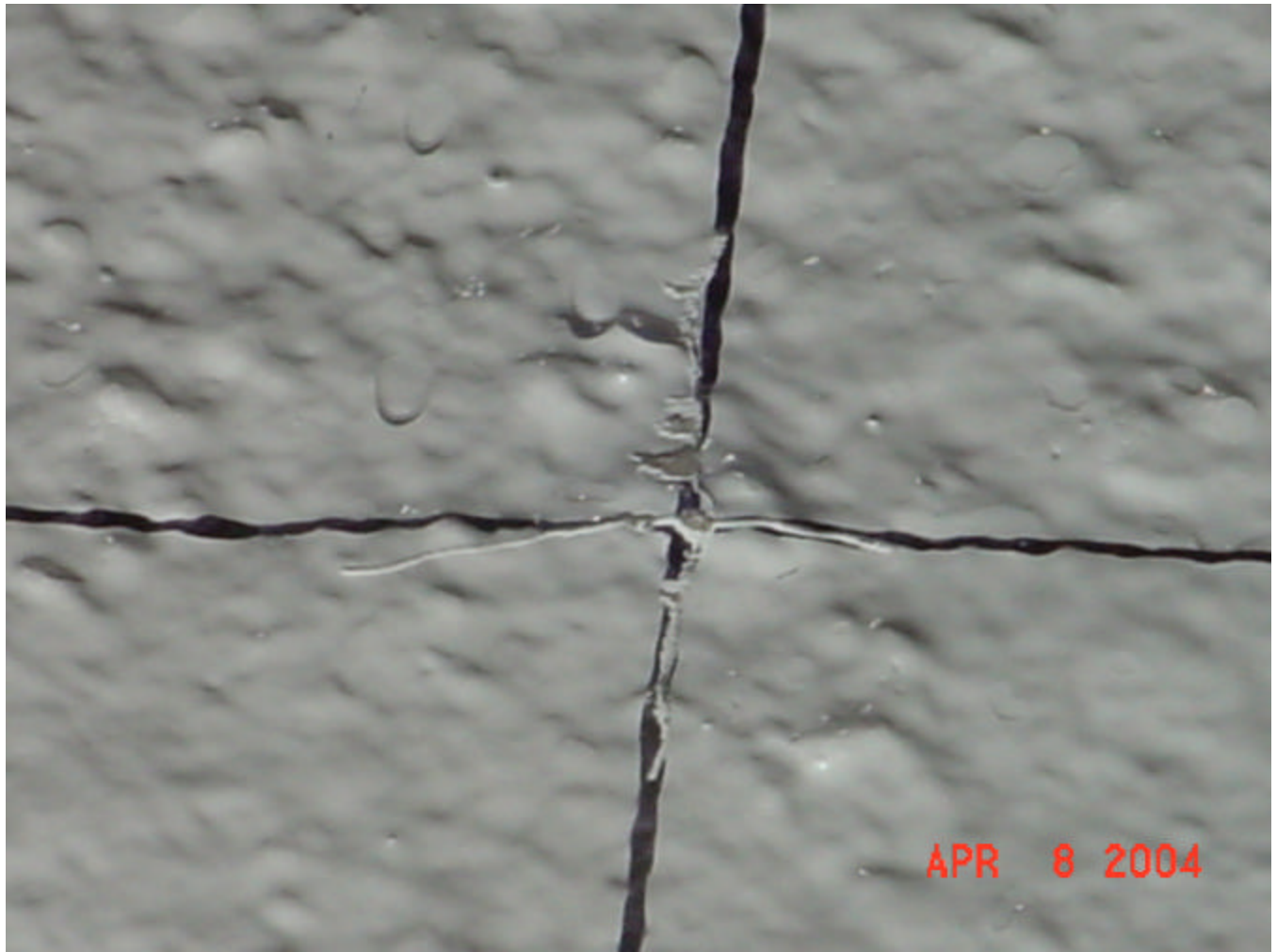


Figure A-19. Test Area 8, After 6 in. Standoff (Closeup)

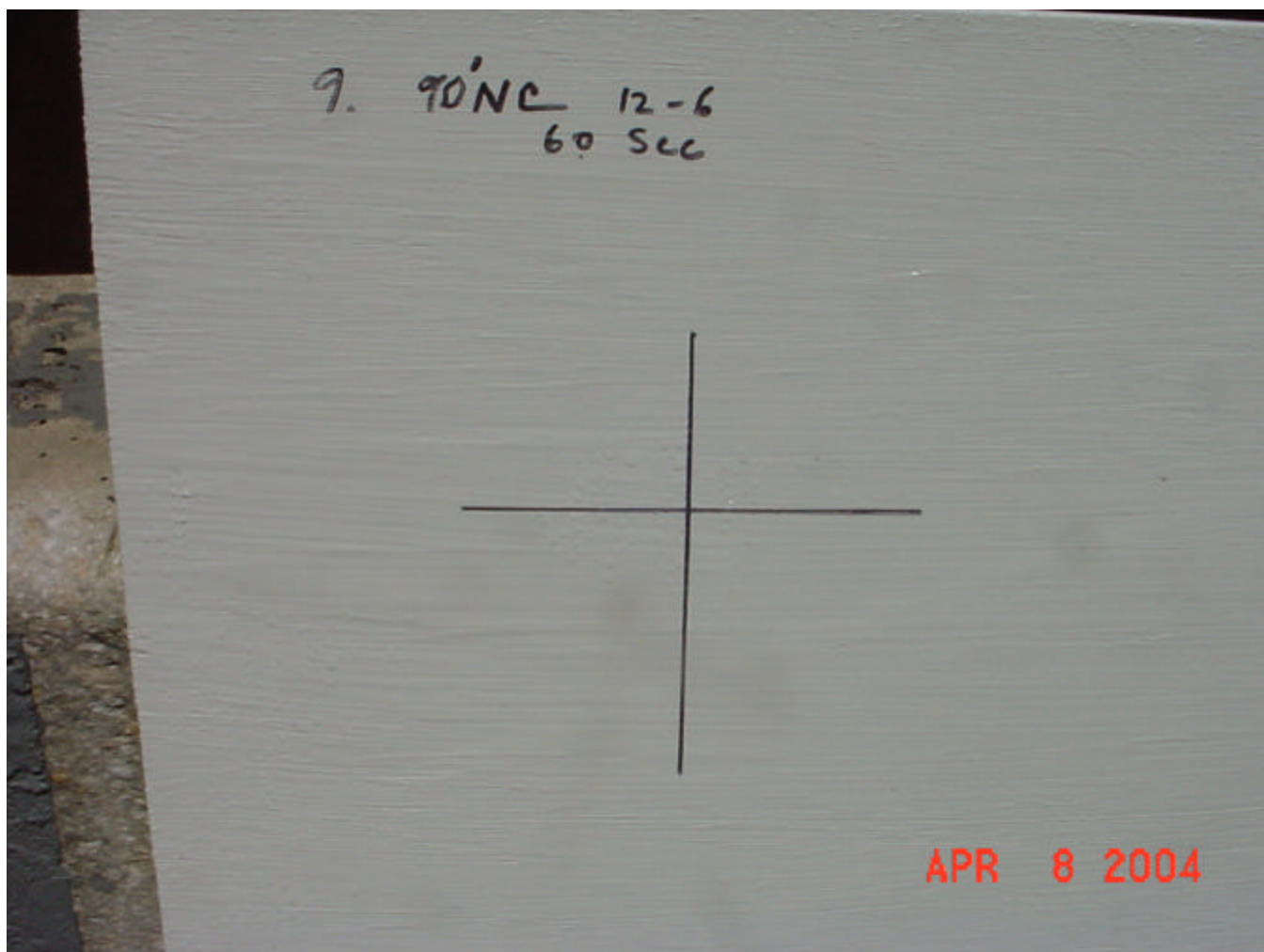


Figure A-20. Test Area 9, After 6 in. Standoff



Figure A-21. Test Area 9, After 3 in. Standoff (Closeup)

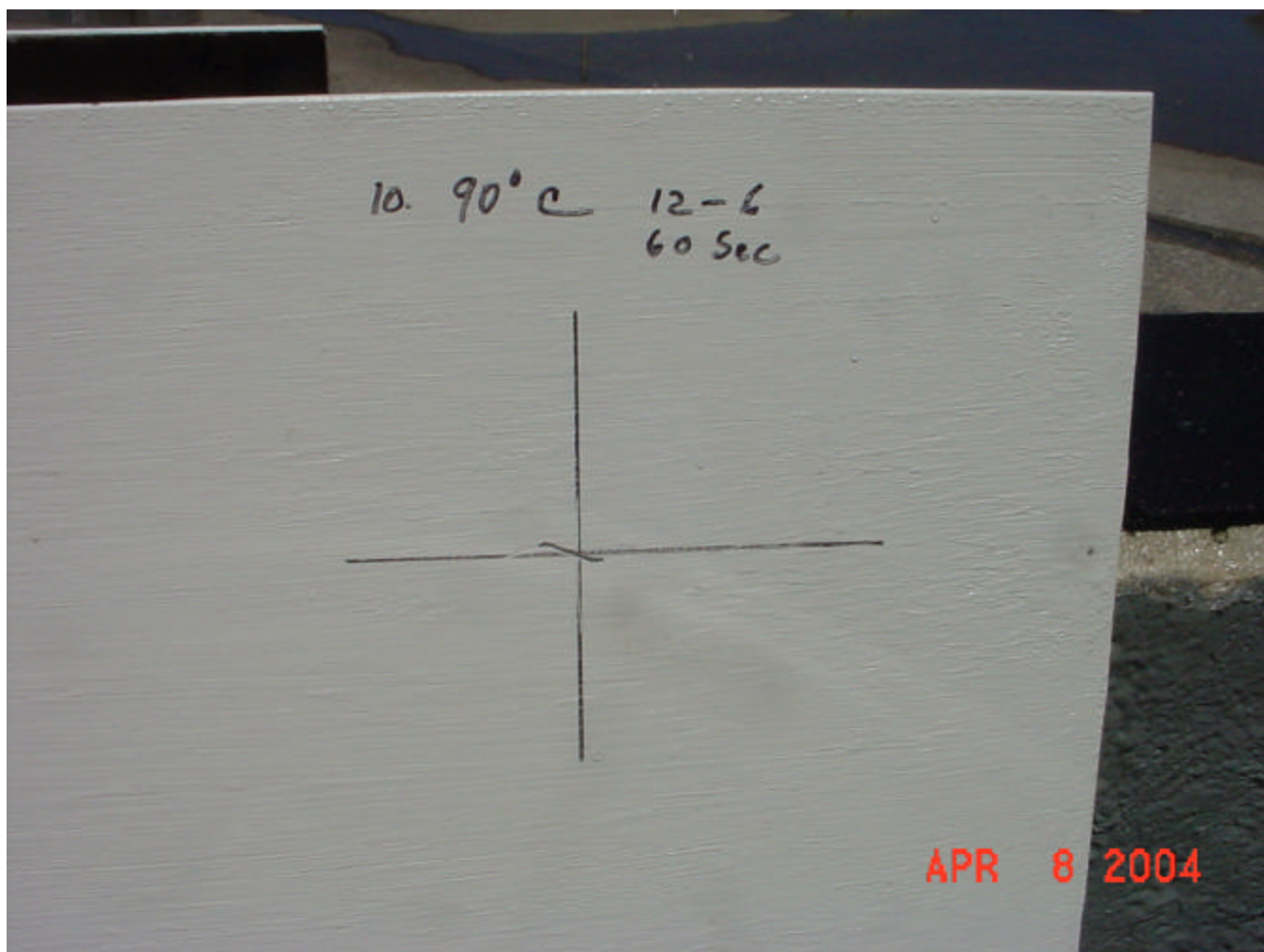


Figure A-22. Test Area 10, After 6 in. Standoff



1
2

Figure A-23. Test Area 10, After 3 in. Standoff (Closeup)

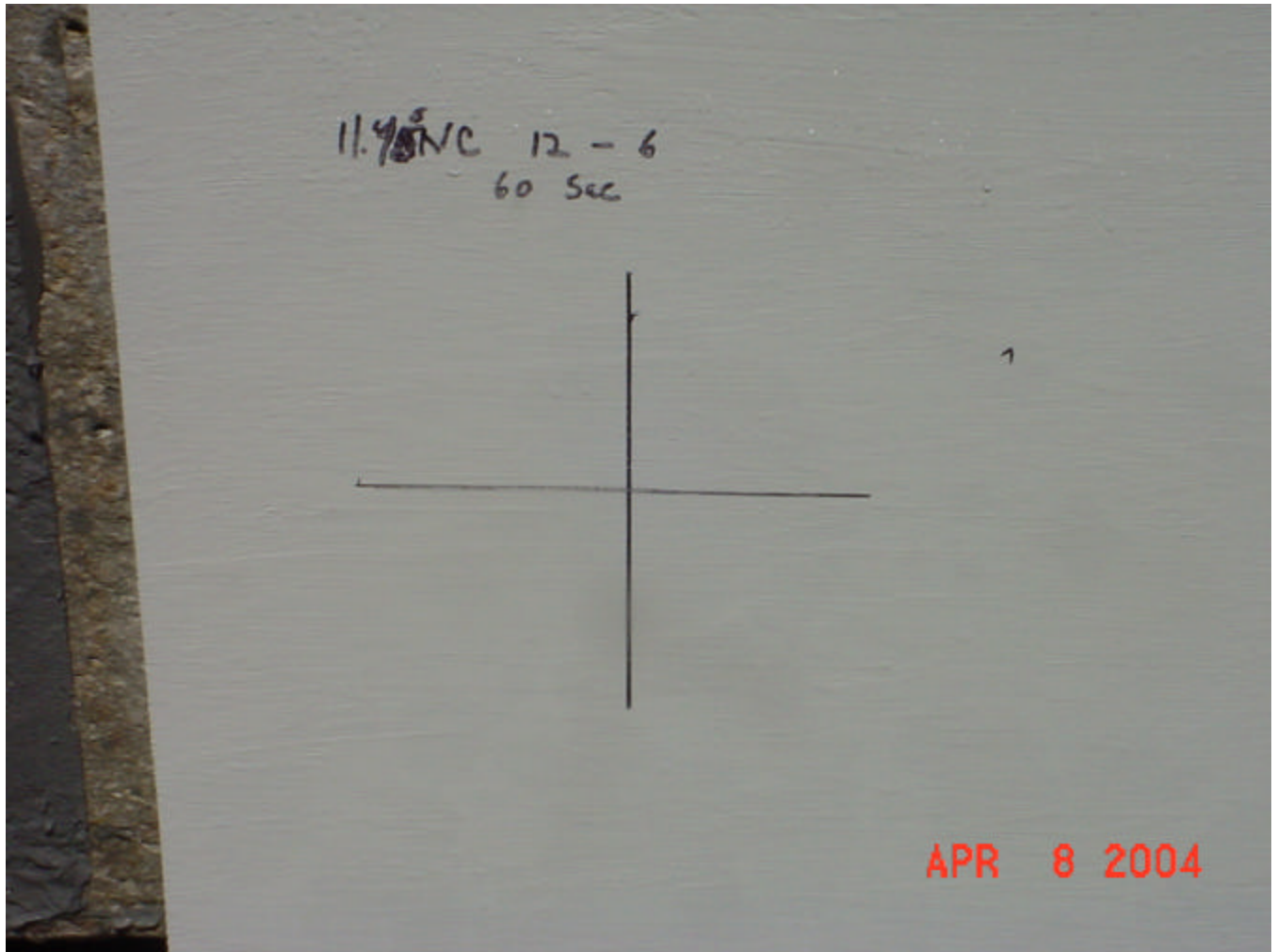


Figure A-24. Test Area 11, After 6 in. Standoff

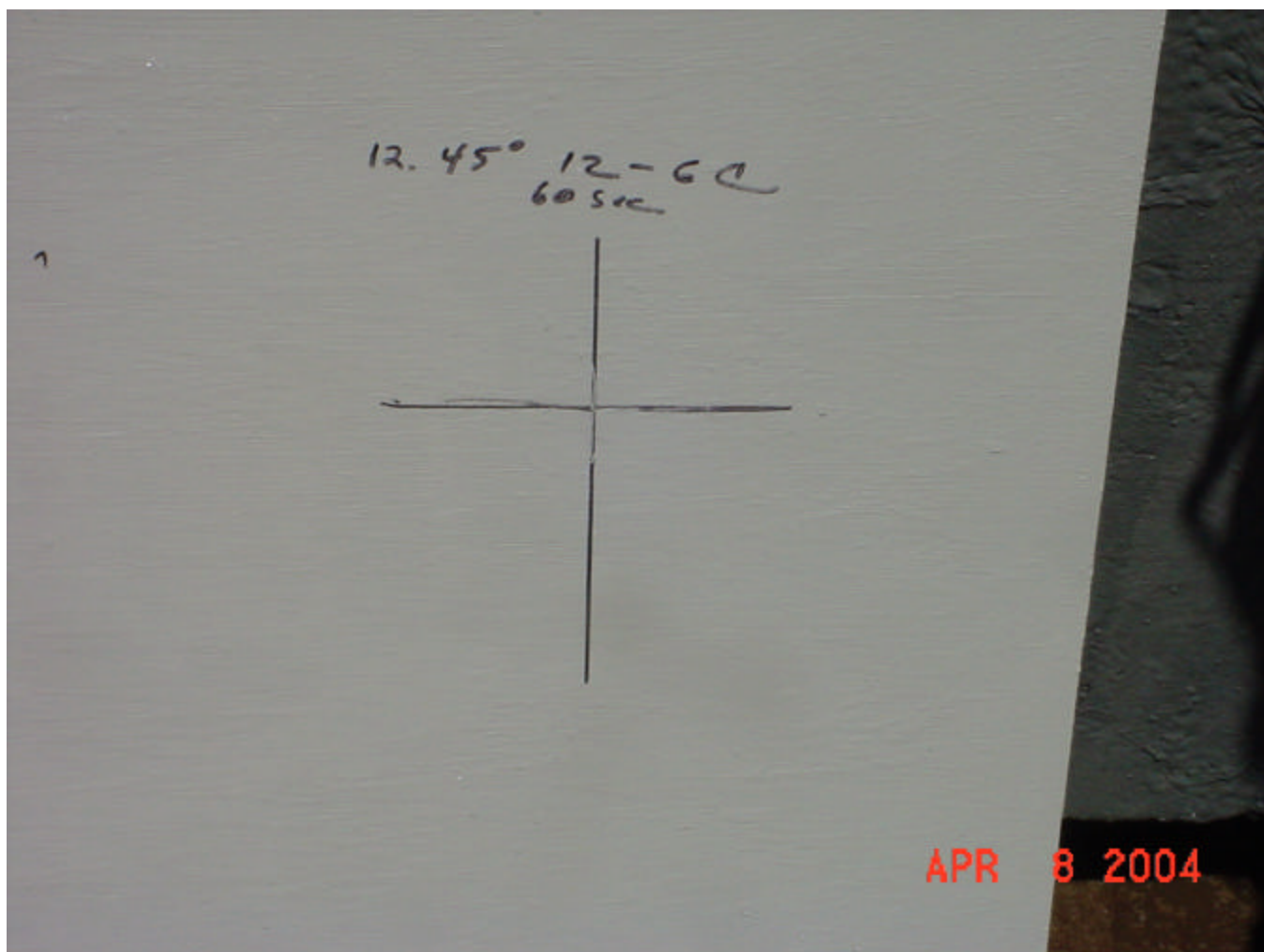


Figure A-25. Test Area 12, After 6 in. Standoff



Figure A-26. Test Area 12, After 6 in. Standoff (Closeup)

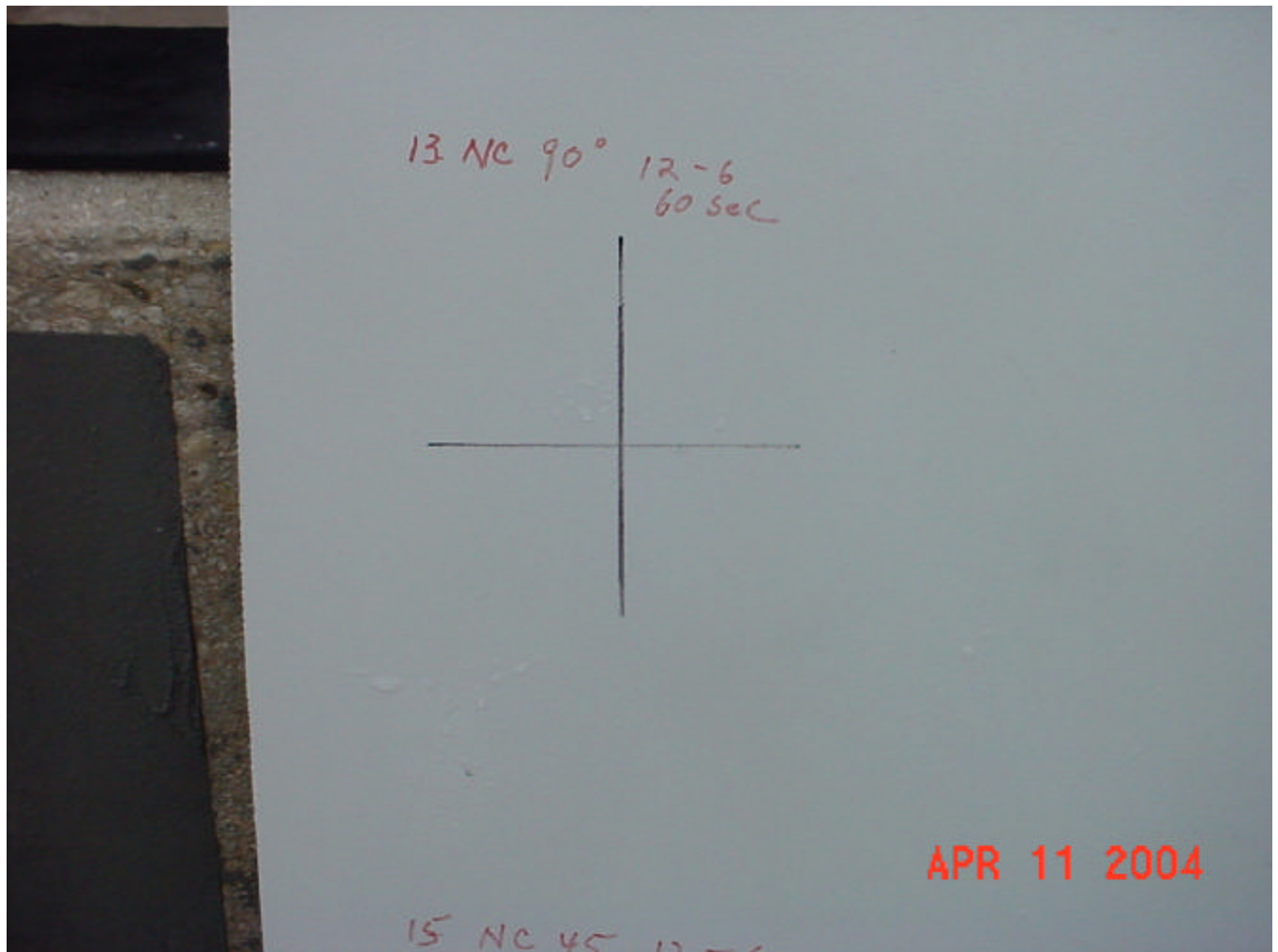


Figure A-27. Test Area 13, After 6 in. Standoff

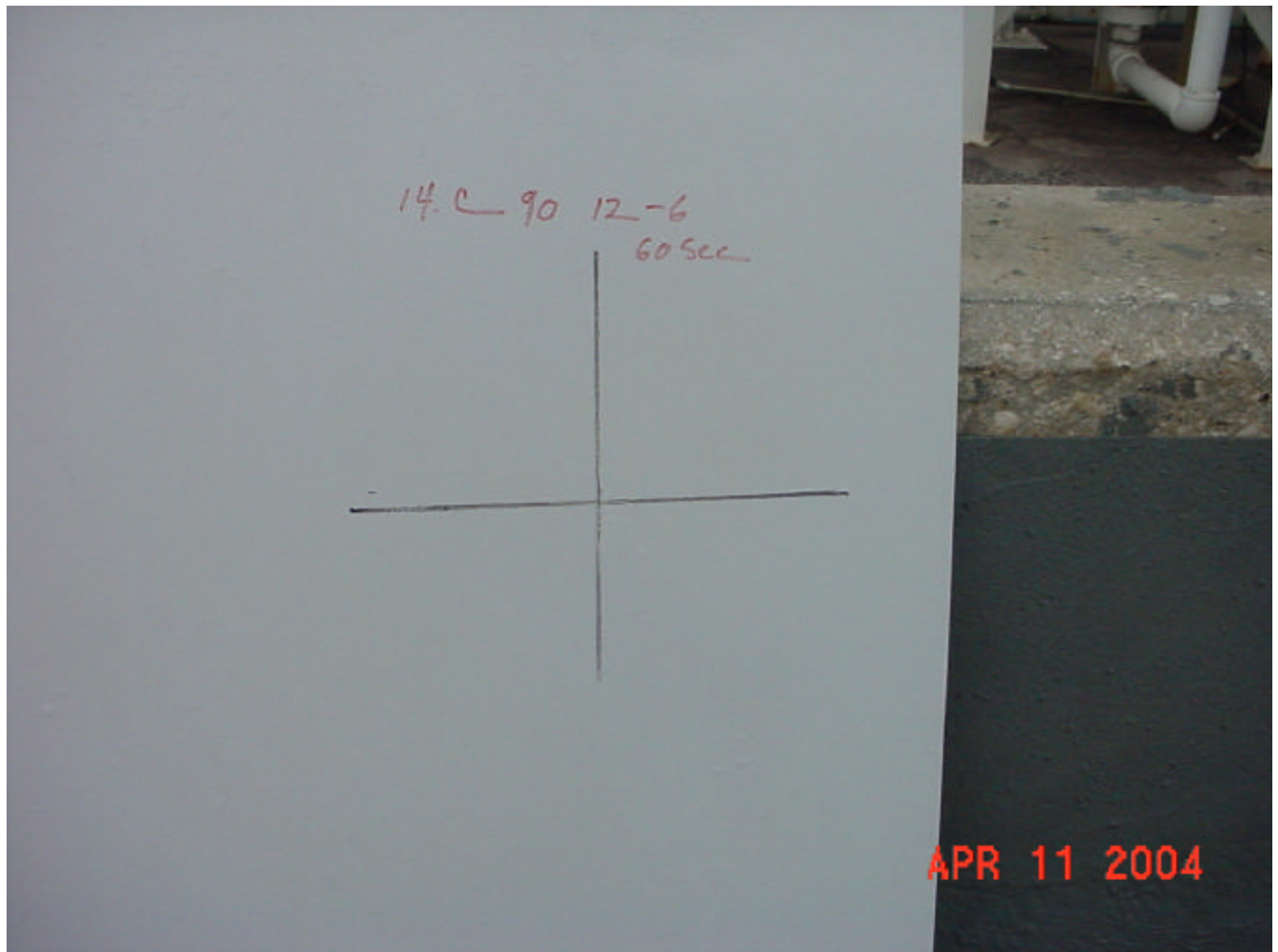


Figure A-28. Test Area 14, After 6 in. Standoff

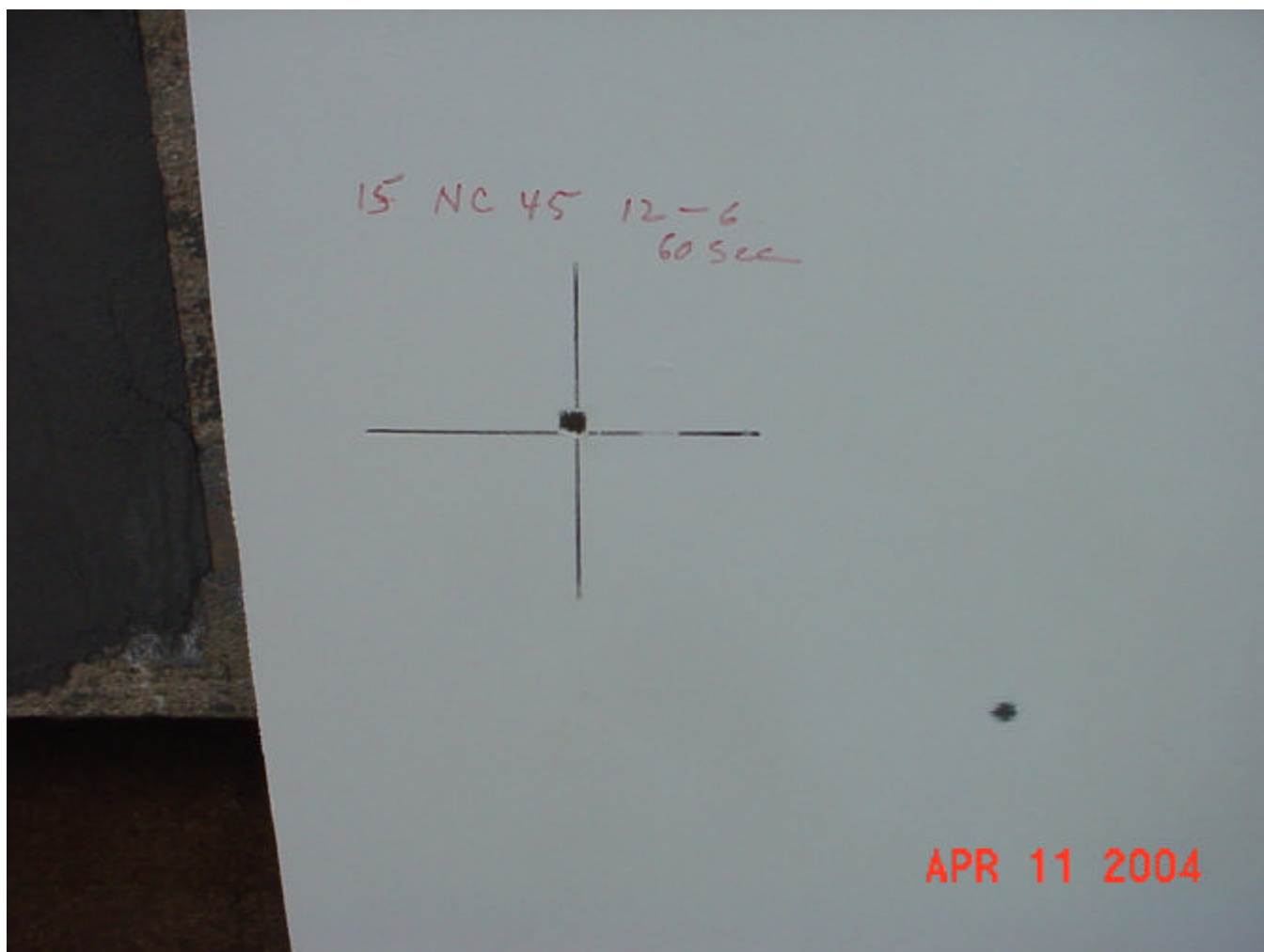


Figure A-29. Test Area 15, After 6 in. Standoff

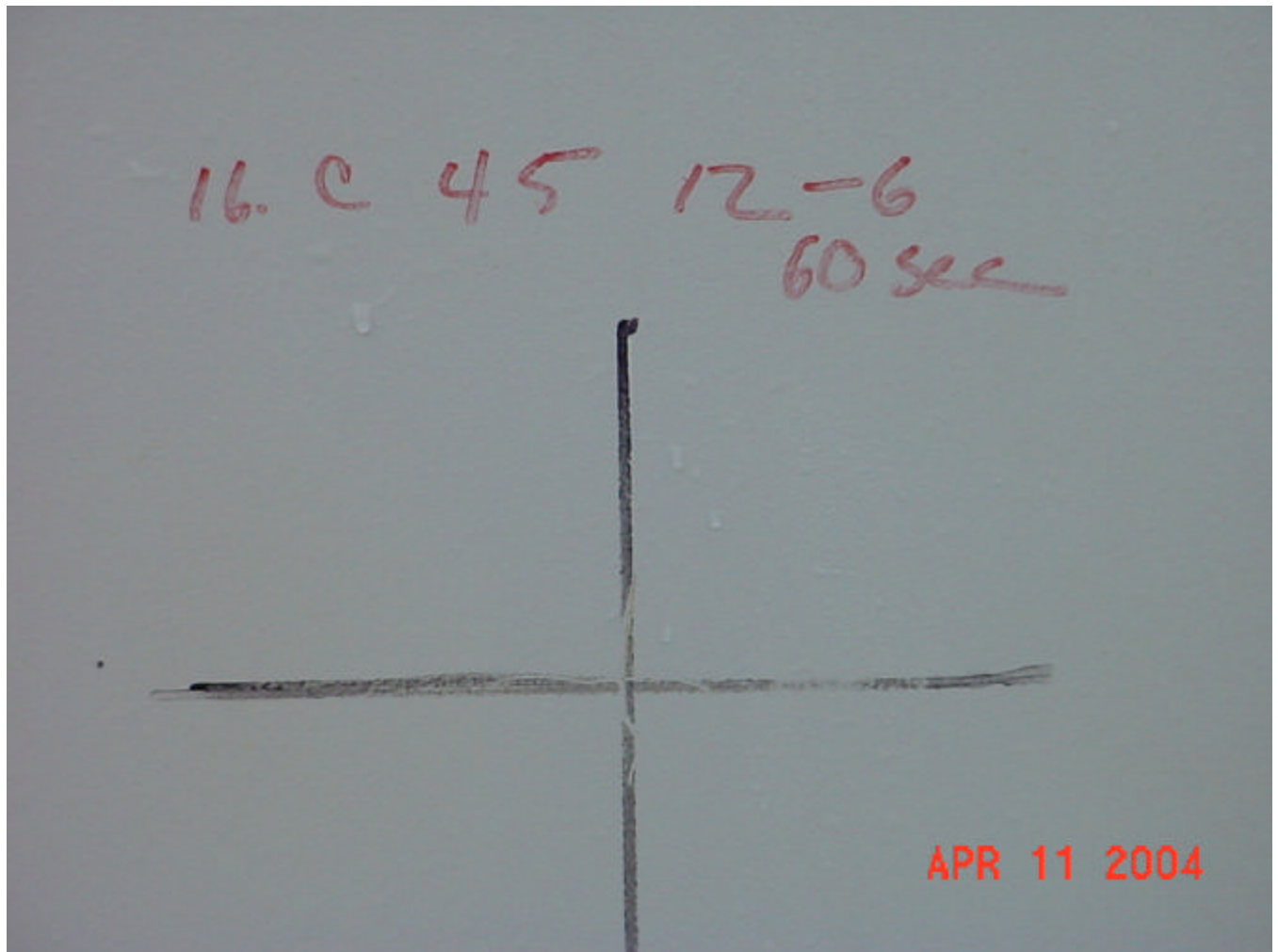


Figure A-30. Test Area 16, After 6 in. Standoff

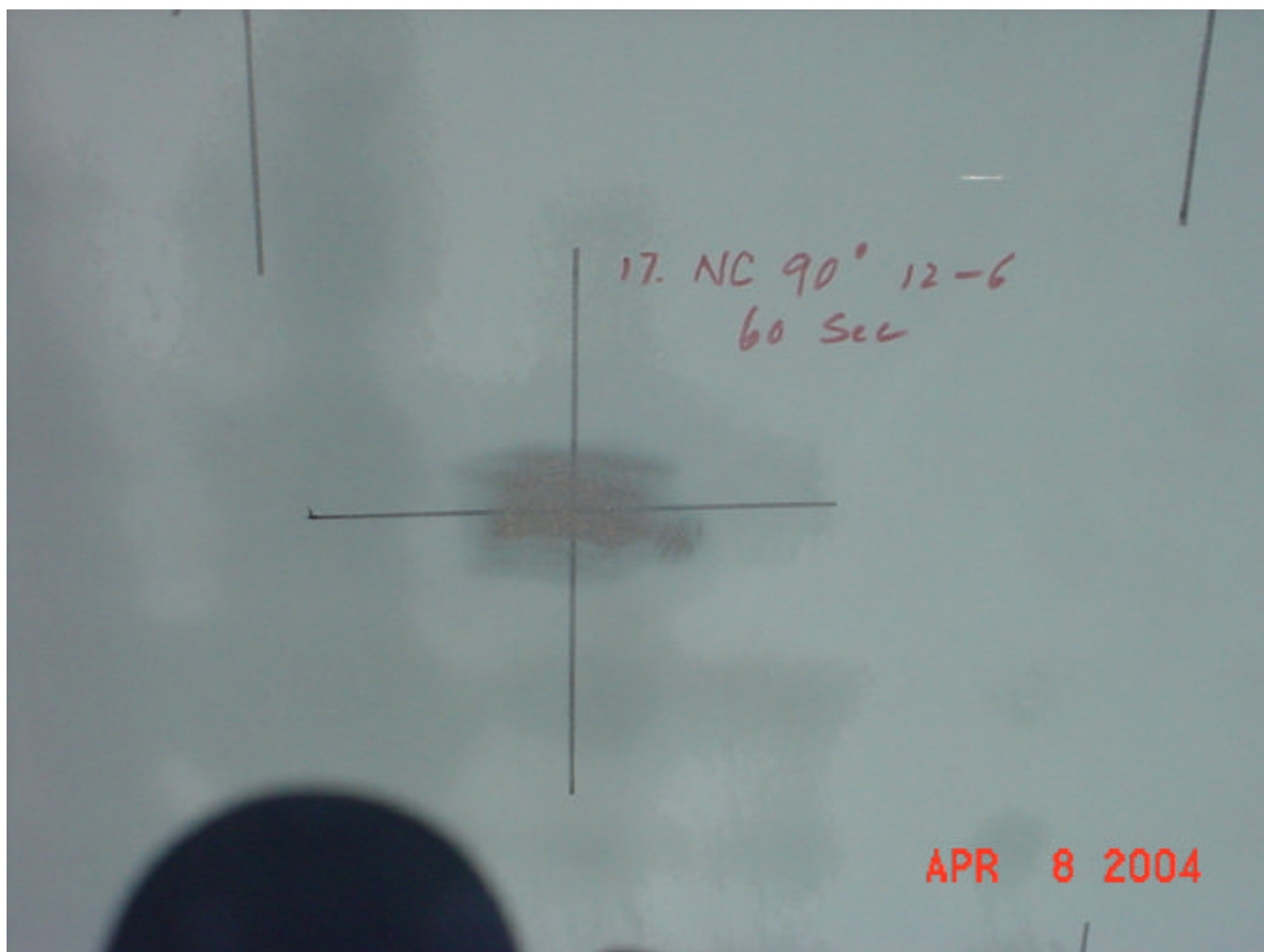


Figure A-31. Test Area 17, After 6 in. Standoff

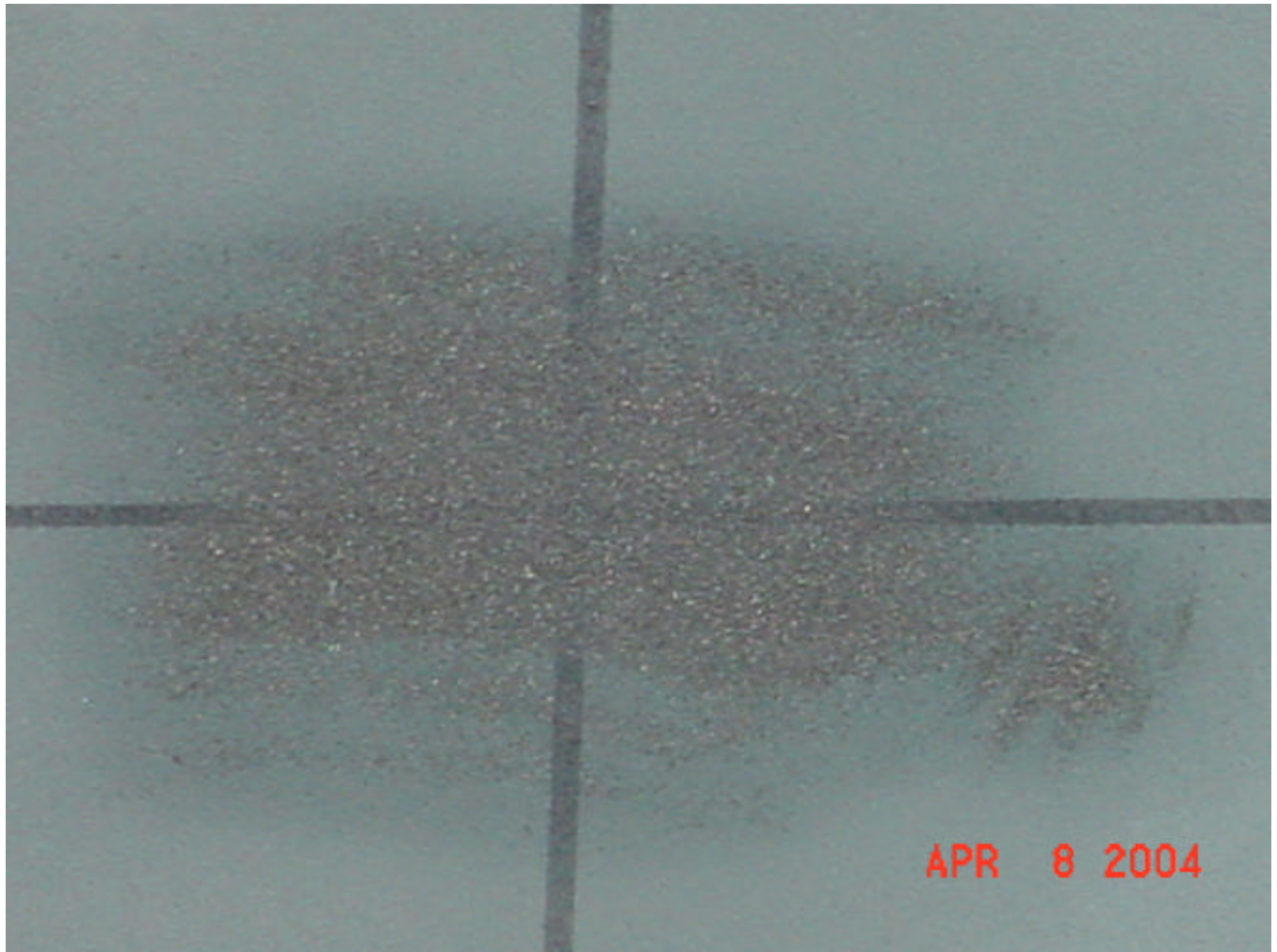


Figure A-32. Test Area 17, After 6 in. Standoff (Closeup)

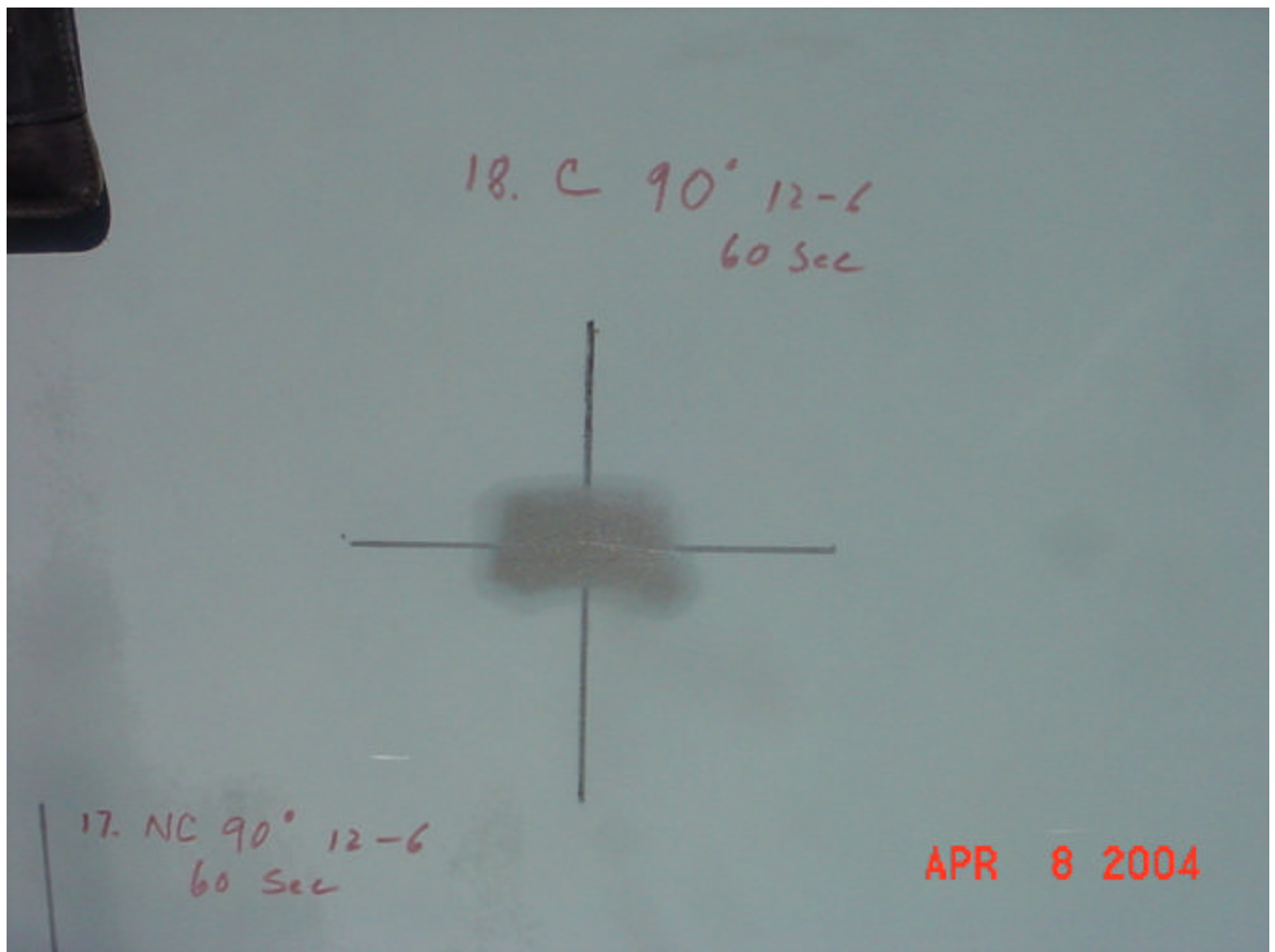


Figure A-33. Test Area 18, After 6 in. Standoff

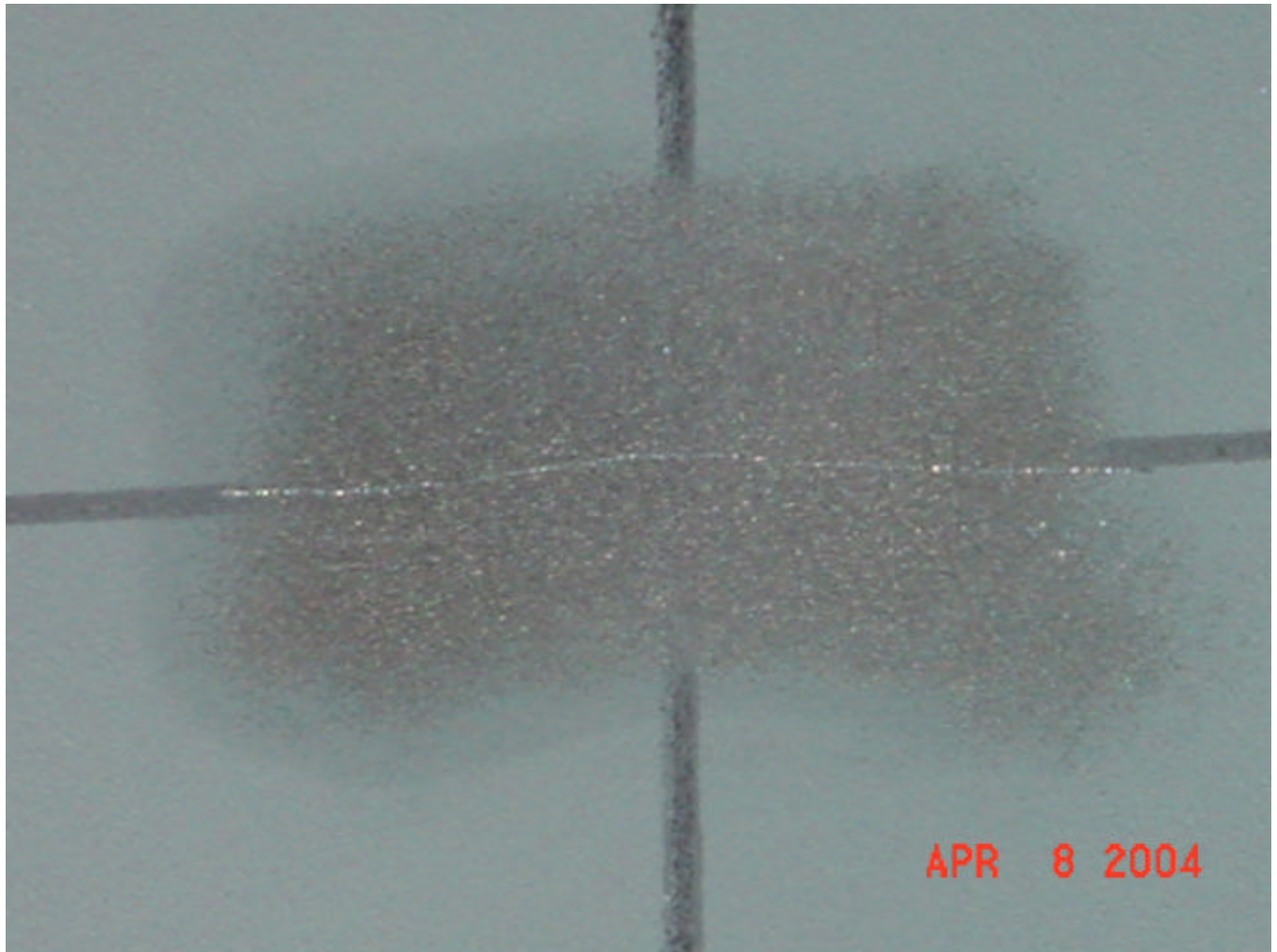


Figure A-34. Test Area 18, After 6 in. Standoff (Closeup)

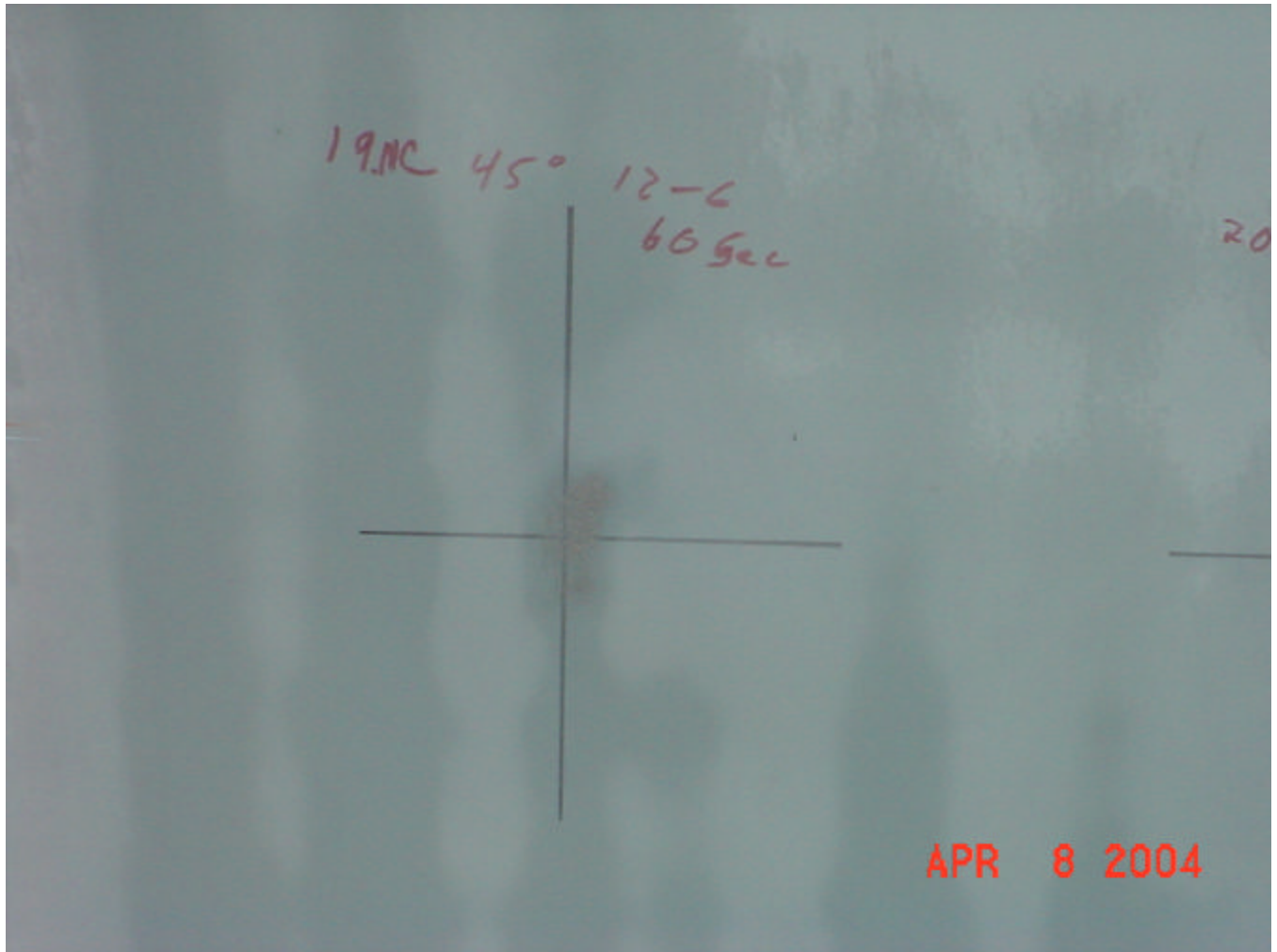


Figure A-35. Test Area 19, After 6 in. Standoff



Figure A-36. Test Area 19, After 6 in. Standoff (Closeup)

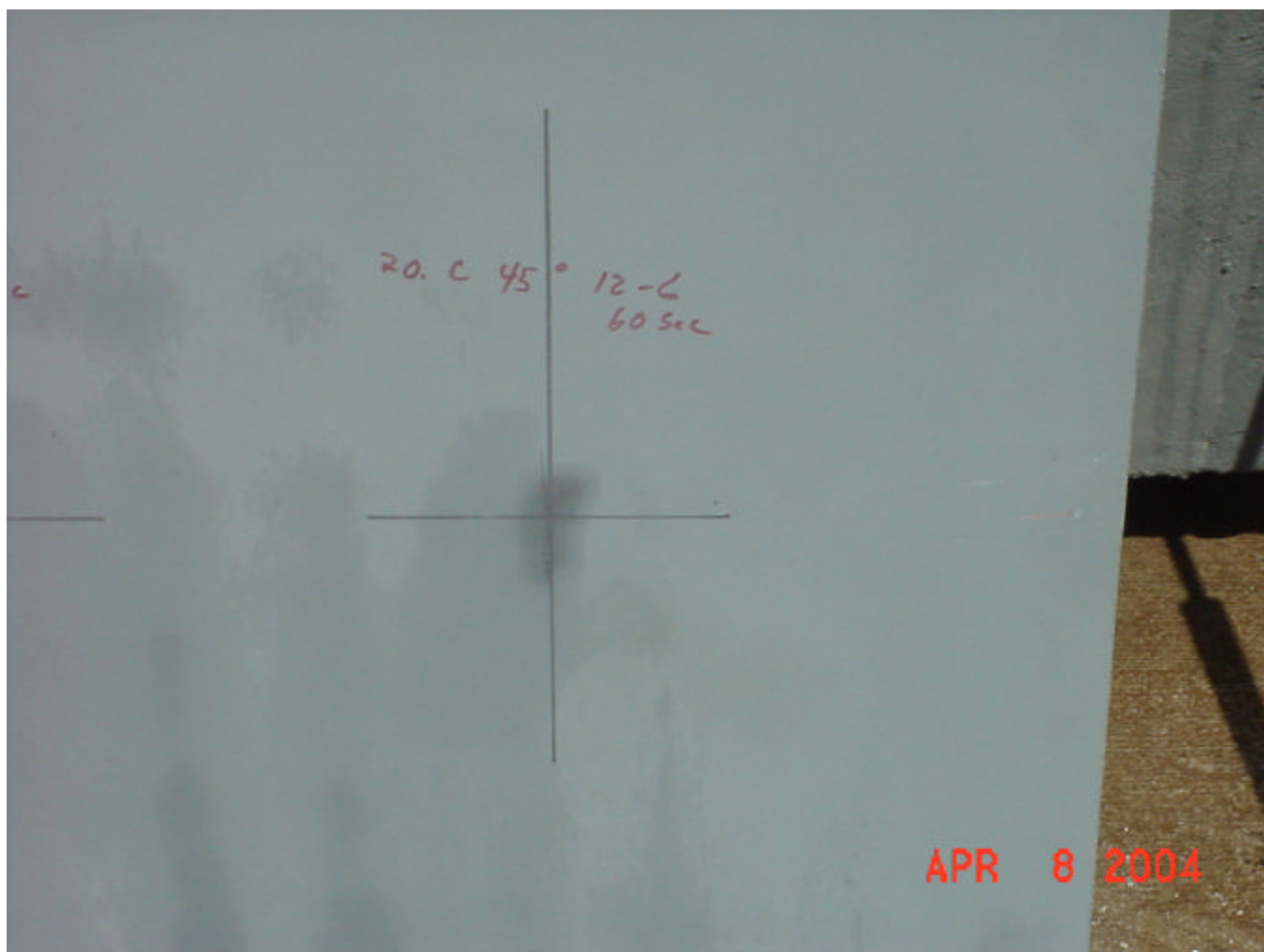


Figure A-37. Test Area 20, After 6 in. Standoff

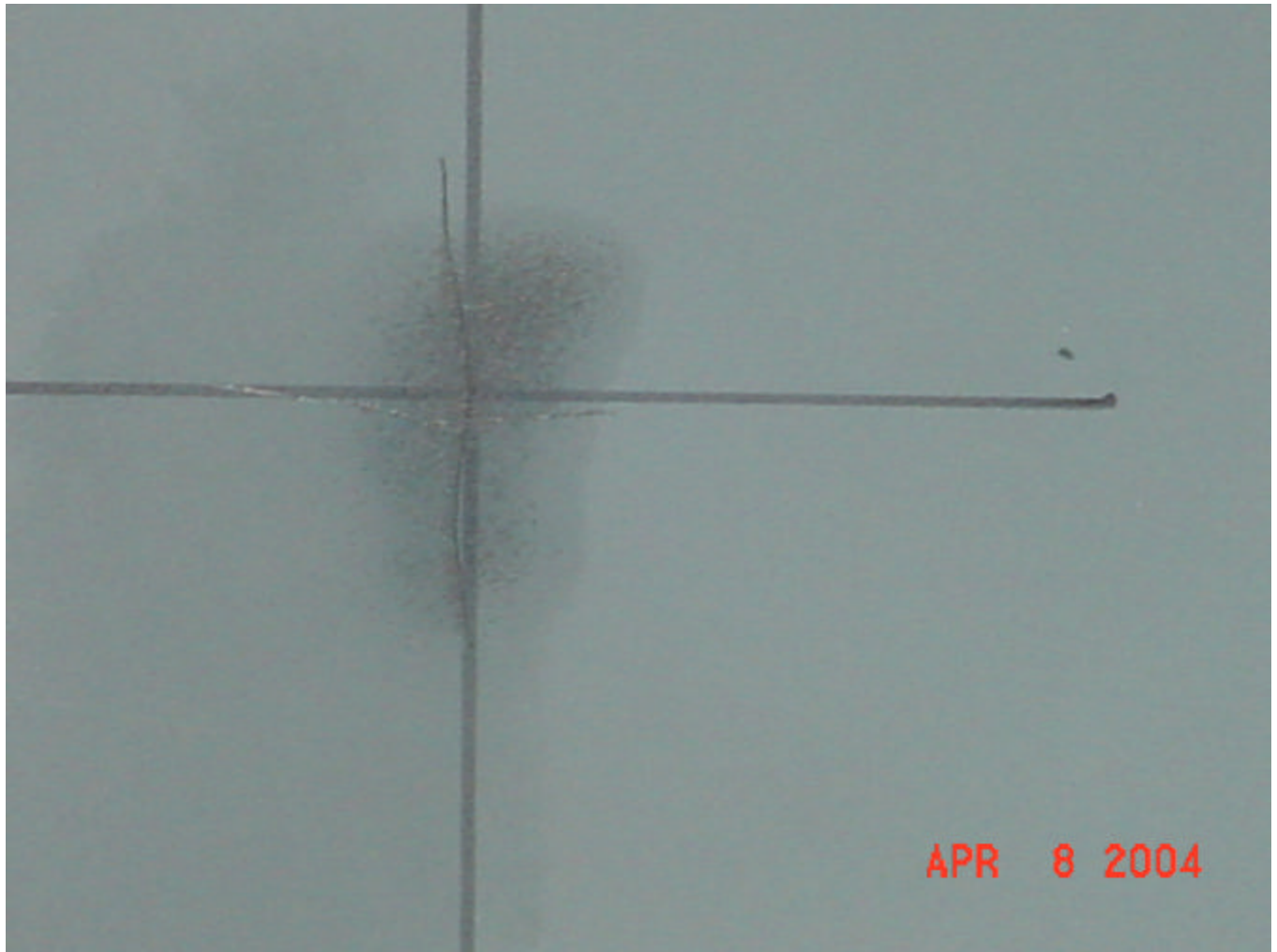


Figure A-38. Test Area 20, After 6 in. Standoff (Closeup)